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A SURVEY OF AVERAGE DRIVING PATTERNS IN THE MINNEAPOLIS-ST PAUL URBAN AREA

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A SURVEY OF AVERAGE DRIVING PATTERNS IN THE MINNEAPOLIS-ST. PAUL URBAN AREA

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February 13, 1970

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INTRODUCTION

System Development Corporation (SDC) has performed a study to survey the characteristic use patterns of privately operated automobiles in the Minneapolis-St. Paul urban area. The study was conducted under jointly sponsored research contracts to the National Center for Air Pollution Control, Department of Health, Education, and Welfare, and the Coordinating Research Council, Inc. The purpose of the study was to obtain data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices.

During the study SDC installed automatic information recording devices -- called Tachographs -- in 125 privately operated automobiles volunteered by Minneapolis-St. Paul area residents. The data records from these instruments as well as information obtained from log books maintained by each of the volunteer participants have been reduced and analyzed. This document presents a discussion of the study results and a comparison of these results with the findings of similar surveys conducted previously in Los Angeles, California; Houston, Texas; Cincinnati, Ohio; and Chicago, Illinois.

This report is published as Volume IV of SDC document series TM-(L)-4119. Volume 0, A Survey of Average Driving Patterns in the Los Angeles Urban Area presents in addition to the Los Angeles survey findings a description of the survey technique as well as the data reduction and statistical analysis procedures. Since the technique and procedures used for collecting and analyzing the Minneapolis-St. Paul data are essentialiy the same as those employed for Los Angeles, reference is made to Volume 0 for information in these areas.

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RESULTS OF STUDY

This chapter presents the results of the Survey of Average Driving Patterns in the Minneapolis-St. Paul urban area. The results are organized into three sections. The first presents a detailed description of the several average or typical[1] driving patterns that were developed from a statistical analysis of the survey data. The second section presents a summary description of the data base from which the typical patterns were derived. The third section presents a comparison between the Minneapolis-St. Paul results and the results of the surveys carried out previously in Los Angeles, Houston, Cincinnati and Chicago using statistical analytical techniques to determine similarities and differences in the driving habits of the citizens of the five cities.

TYPICAL DRIVING PATTERNS

SDC's intent in deriving the typical driving patterns described below has been to extract from a large amount of information collected during the survey a fairly detailed quantitative and qualitative description of those patterns which clearly stand out as typical. While the data base is large, it is not so large that the analyst can, with great confidence, probe very deeply into the intricacies of secondary or tertiary patterns. Nevertheless, in view of the scarcity of previous results in this area of study, particularly from the standpoint of enlisting the public's aid in the data collection effort, the results presented here represent a substantial contribution to our knowledge of automobile utilization--even if they only serve to reinforce what have heretofore been intuitive concepts about how people drive their cars.

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[1] SDC prefers the term "typical" to the term "average" since the latter has the connotation of an arithmetic mean which in the present case is not entirely appropriate. The typical driving patterns are, in most aspects of the analysis, derived from modes rather than means in the statistical sense.

A typical driving pattern is described in terms of a day's sequence of trips that all start at approximately the same time, have the same trip segment string (i.e., have identical patterns of freeway and nonfreeway usage), and can be explained by a reasonable scenario of driver behavior. The patterns described below are those which stand out clearly in the results of the analysis. Part of the description of each pattern is an indication of the percentage of the entire survey sample represented by the pattern as well as the percentage of the n-trip sample which is characterized by the n-trip pattern. Figure 1 shows the distribution of n-trip days for the seven days of the week.

Table 1 shows the distribution of complete weekdays and weekend days[1] upon which survey participants drove their cars on n-trips. In the Minneapolis-St. Paul survey, n varied from zero to 16 on both weekdays and weekends. The table shows that the occurrence of days on which more than five trips were driven drops off quickly compared to days on which five or less were driven. Partly because of the dropoff in sample size as the number of trips increased, but more importantly because the potential number of trip patterns increases geometrically as the number of trips per day increases, patterns were discovered only for two-, three-, four-, and five-trip sequences.

Again, as in Los Angeles, Houston, Cincinnati and Chicago, no clear-cut patterns were discernible for weekend driving. The time distribution of weekend trips is quite different from that of weekday trips (see Figures 12 and 13). The incidence of n-trip days also varies considerably between weekend days and weekdays. To some extent this difference may be more marked in our survey due to the composition of the survey population. All participants in the survey were contacted through their place of employment. Consequently, the daily schedule imposed upon a working employee tends to be reflected in

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[1] A complete day is one for which data were obtained for the entire day's operation or for which data on two half-days of operation were available and could be merged to make a single day's operation.

FIGURE 1

FREQUENCY OF N-TRIP DAYS BY DAY OF WEEK

TABLE 1

DAILY DISTRIBUTION OF COMPLETE N-TRIP
DAYS IN MINNEAPOLIS-ST. PAUL DRIVING PATTERNS SURVEY

NUMBER OF TRIPS PER DAY (N)	NUMBER OF N-TRIP DAYS							
	M	T	W	TH	F	S	S	TOTAL
0	10	8	5	3	4	21	34	85
1	2	3	1	3	2	1	4	16
2	21	21	28	22	15	10	13	130
3	15	13	11	10	17	8	16	90
4	23	30	23	22	26	17	14	155
5	11	12	10	18	19	15	12	97
6	7	9	12	13	12	10	8	71
7	9	7	11	10	6	7	3	53
8	8	10	8	5	9	7	7	54
9	2	1	3	5	4	6	5	26
10	4	1	2	3	2	5	0	17
11	3	1	1	1	0	5	1	12
12	1	1	0	0	0	1	0	3
13	2	0	2	2	1	3	0	10
14	0	0	1	0	1	1	0	3
15	0	0	0	0	0	0	1	1
16	0	1	0	1	0	1	0	3
TOTAL	118	118	118	118	118	118	118	826

the survey results. Weekday-weekend differences are discussed more fully in each of the remaining sections of the text.

In analyzing the typical n-trip day patterns, differences in the occurrence of particular trip segment strings require that two alternative trips be considered as components of the pattern in certain cases. Also, two distinct patterns for the four-trip day were discovered that require alternative descriptions.

The following sections of the chapter describe each sequence, or pattern, of trips in terms of a scenario and a table of values for such trip descriptors as start time, trip and segment distance, segment average speed, number of momentary stops (idles) per segment, idling time per segment,[1] route types, and purpose of trip. The quantities tabulated for start time, distance, average speed, number of momentary stops (idles), idling time, route type and purpose of trip are the mean values associated with trips and segments that are defined by the specified time slot, purpose, and trip segment string. Adjacent to these values are ranges within which at least 75 percent of the data lie. These ranges are obtained by examining a printout of the distribution of cases for each variable as specified by time slot, purpose, and trip segment string. In the printout, variables are grouped into class intervals. The class intervals used by the program are as follows:

---

[1] In the Los Angeles Survey a linear regression model was made to convert number of momentary stops to idling time. Because of the wide variance in measured idle time as a function of number of stops, we expressed reservations about this approach in the Los Angeles report. (See D. H. Kearin, R. L. Lamoureux, A Survey of Average Driving Patterns in the Los Angeles Urban Area, System Development Corporation, TM-(L)-4119/000/01A, June 2, 1969, pp. 1-56, 2-18). In the Minneapolis-St. Paul analysis, as in the Cincinnati, Houston, and Chicago analyses, we have discarded the use of the regression model and have included as idling time only that which was actually recorded on the Tachograph disc (i.e., the summation of all idling periods in excess of 40 seconds). Therefore, in evaluating idle time figures, one must consider both the number of momentary stops, which indicate the extent of short idling periods of indeterminant length, and the mean idling time, which represent estimates of the expected sum of any extended periods of idling.

Distance: 1-mile intervals from 0 miles to 60 miles.
Average speed: 5-mph intervals from 0 mph to 75 mph.
Momentary stops: 1-stop intervals from 0 to 30 stops.
Idling time: 1-minute intervals from 0 to 10 minutes.

To calculate the 75-percent ranges for distance, speed, and idling time, the analyst starts with the class interval that contains the mean, and working away from that interval in both directions, sums the number of cases until he has included at least 75 percent of them. The number he accumulates in each direction depends on the way the data are distributed: For distributions skewed in the lower direction, more cases will be picked up below the mean; for symmetrical distributions, the range will be more balanced. The time slots used for grouping the data were agreed upon earlier by CRC[1] and SDC. Weekdays are divided into eight time slots, weekend-days into six. Table 2 shows the organization of the time slot structure.

TABLE 2

TIME SLOT STRUCTURE USED IN
MINNEAPOLIS-ST. PAUL DRIVING PATTERNS SURVEY

TIME SLOT NUMBER	TIME PERIOD (24 HOUR CLOCK)	
	WEEKDAY	WEEKEND
1	0000-0559	0000-0829
2	0600-0859	0830-1059
3	0900-1129	1100-1259
4	1130-1329	1330-1759
5	1330-1629	1800-2059
6	1630-1829	2100-2359
7	1830-2059	—
8	2100-2359	—

[1] CRC-APRAC Project Groups CAPE-5 and CAPE-10.

The time distribution of all trip start times is shown in Figures 12 and 13 in the General Results section of this chapter.

The elapsed time for each component trip of a typical trip pattern is based on completing the mean trip or segment distance at the mean average speed. The reason for calculating mean elapsed time from mean distance and mean average speed is twofold. First, as described in the pattern descriptions, certain trip distances are derived artificially so that no data on real elapsed time over these distances are available. Second, and more important, the Tachograph provides distance and elapsed time for each trip from which exact average speed values are calculated. The values of these three variables are, however, continuously distributed from the standpoint of the computer. In order to meet computer storage requirements and to obtain distribution information, these variables must be grouped or classified into the class intervals previously listed. Once this is done, mean speed, mean trip distance and mean elapsed time are no longer functionally related in exact terms since all calculations use the midpoint of the class interval to represent all the values within that interval. Therefore, the authors believe that the average speed and average distance are more "real" intuitively since they are descriptive of actual, not artificial, phenomena that occurred during the survey, and that elapsed time can best be calculated using the mean values for these variables rather than using the mean values for time and distance to calculate mean average speed. Variations over the ranges for distance and speed will, of course, cause differences in the elapsed time of the trip or segment.

A general description of the method used in deriving these patterns is contained in the Statistical Analysis section of Part III of the Los Angeles report.[1] The section on general results that follows the description of the typical trip patterns discusses in greater detail the quantitative basis for the patterns described.

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[1] Ibid., pp. 3-1 to 3-16.

The Two-Trip Day

Figure 2 shows the time dependency distribution of all two-trip weekdays that occurred during the survey period in Minneapolis-St. Paul. The presentation is in the form of a trip-to-trip transition matrix. The matrix is set up as follows: All trips are assigned a time slot value based on the time slot into which one-half or more of the total trip time falls. These time slot values for all trips one and two on two-trip days were analyzed to determine into which cell of the trip-to-trip transition matrix the day's record would be counted. The time slot value for trip one established the row for the entry, the time slot value for trip two established the column. Therefore, if a trip one occurred in time slot two followed by a trip two in time slot six, the record for that day was associated with cell 26 at the intersection of the second row and the sixth column. In addition to the slot dependencies, the analysis also provided counts for purpose-to-purpose dependencies within each time slot cell. It is from these latter dependencies that the literal entries in Figure 2 indicating the typical purpose-to-purpose pairs are obtained. In Figure 2 and subsequent trip-to-trip transition matrices these literal entries are made only for cells with high frequency trip entries and then only if a particular purpose pair stands out.

From Figure 2, we see that the highest frequency count occurs in cell 26 with 74 two-trip days showing the transition. Of these 74, 65 show the purpose-to-purpose combination of a trip one, to work, followed by a trip two, to home. That this is a typical trip pattern is clear. Reinforcement is added by the fact that 13 trips in the adjacent cell 25 as well as four trips in cell 27 show the same purpose-to-purpose structure. If one assumes that the 13 in cell 25 represent people with early quitting times, say between 4:00 and 4:30 p.m., while the four in cell 27 represent overtime workers, then the analysis shows that between 65 out of 107 (61%) and 82 out of 107 (77%) of the two-trip days fit our typical pattern. This range represents between 11.0% and 13.9% of the total complete car-weekdays in the survey.

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859	0	1	0	16 W-H	74 W-H	5	1	
0900-1129	1	0	0	0	1	0		
1130-1329	1	0	0	0	1			
1330-1629	0	1	0	0				
1630-1829	1	2	0					
1830-2059	0	2						
2100-2359	0							

TRIP ONE TO TRIP TWO

TOTAL TWO-TRIP DAYS: 107

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 2

TWO-TRIP WEEKDAY TRANSITION MATRIX

The values for the typical two-trip pattern are shown in Table 3. In the first column, entitled Trip Number, the letter "A" represents a nonfreeway trip while the letter "B" represents a freeway trip. The trip-to-work in time slot two on weekdays is more likely to have a trip segment sequence of nonfreeway only rather than nonfreeway/freeway/nonfreeway (the survey contained 334 of the former, 200 of the latter). However, because a substantial number of work trips in this time period do have the nonfreeway/freeway/nonfreeway configuration, we believe that both should be accounted for. The Minneapolis-St. Paul data tend to indicate that weighting factors of three-fifths and two-fifths should be assigned respectively to the N and the NFN trip segment string work trips in time slot two. This weighting assignment is also used in the subsequent three-, four-, and five-trip day patterns. The data for return trips home in time slot six are confused by the incidence of return trips from origination points other than work. Realizing that the decision is arbitrary, we have chosen to assign the same structure to the return trip from work that is shown in the morning trip to work. Therefore, the distances shown in Table 3 for the evening trip are the same as those in the morning trip. The average speeds for both trips, however, are those characteristic of the time slot, purpose, and trip segment string described. The elapsed times are calculated from these values. The values for trip stops engine running and idle time are adjusted to be proportional to the average distance traveled.

The Three-Trip Day

Figures 3 and 4 show the two trip-to-trip transition matrices for complete three-trip days in the Minneapolis-St. Paul survey. The matrix in Figure 3 shows the transition from trip one to trip two; that in Figure 4 from trip two to trip three.

The predominant transition in the first matrix is from a first trip in time slot two to a second trip in time slot six. In addition, there is a transition of a secondary importance for the adjacent cell representing a second trip in time slot five. Of the total of 36 trips in cell 26, 18 represent the purpose-

TABLE 3

THE TYPICAL TWO-TRIP DAY PATTERN

(REPRESENTS 61%-77% OF ALL TWO-TRIP DAYS, 11.0%-13.9% OF ALL COMPLETE CAR-WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME MEAN	START TIME RANGE*	MEAN ELAPSED TIME (MIN)	DISTANCE (MILES) MEAN	DISTANCE (MILES) RANGE**	AVERAGE SPEED (MPH) MEAN	AVERAGE SPEED (MPH) RANGE**	NUMBER OF STOPS (IDLES) MEAN	NUMBER OF STOPS (IDLES) RANGE**	IDLE TIME (MIN) MEAN	IDLE TIME (MIN) RANGE**
1A	WORK	1	N	0725	0653 - 0757	15.8	6.1	2.0 - 11.0	23.1	15.0 - 40.0	5.6	1.0 - 9.0	0.0	0.0 - 1.0
	OR:													
1B	WORK	1	N	0723	0654 - 0752	6.2	2.9	0.1 - 5.0	28.0	10.0 - 40.0	2.6	0.0 - 4.0	0.2	0.0 - 1.0
		2	F			10.9	7.5	1.0 - 10.0	41.3	30.0 - 55.0	0.3	0.0 - 1.0	0.0	0.0 - 1.0
		3	N			8.1	3.8	0.1 - 6.0	28.0	15.0 - 50.0	2.8	0.0 - 4.0	0.2	0.0 - 1.0
						25.2	14.2				5.7		0.4	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 3 TO 2 RESPECTIVELY														
2A	HOME	1	N	1709	1633 - 1745	15.2	6.1	2.0 - 11.0	24.0	10.0 - 35.0	6.9	0.0 - 10.0	0.4	0.0 - 1.0
	OR:													
2B	HOME	1	N	1658	1629 - 1727	2.6	3.8	0.1 - 5.0	29.9	15.0 - 45.0	3.5	0.0 - 6.0	0.3	0.0 - 1.0
		2	F			10.7	7.5	1.0 - 10.0	42.1	25.0 - 55.0	0.5	0.0 - 1.0	0.0	0.0 - 1.0
		3	N			5.5	2.9	0.1 - 6.0	31.7	15.0 - 50.0	2.2	0.0 - 3.0	0.2	0.0 - 1.0
						23.8	14.2				6.2		0.5	
TRIPS 2A AND 2B OCCUR IN THE RATIO OF 3 TO 2 RESPECTIVELY														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	1	0	0	0	0	0	0
0600-0859	7	1	4	6	36 W-S	0	0	
0900-1129	2	0	0	0	0	0		
1130-1329	0	1	0	0	0			
1330-1629	1	0	0	0				
1630-1829	0	4	0					
1830-2059	3	0						
2100-2359	0							

TRIP ONE TO TRIP TWO

TOTAL THREE-TRIP WEEKDAYS: 66

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 3

THREE-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859	0	0	1	0	7	0	0	
0900-1129	0	0	0	2	0	1		
1130-1329	1	2	1	0	0			
1330-1629	4	4	0	0				
1630-1829	23 S-H	11	2					
1830-2059	5	2						
2100-2359	0							

TRIP TWO TO TRIP THREE

TOTAL THREE-TRIP WEEKDAYS: 66

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 4

THREE-TRIP WEEKDAY TRANSITION MATRIX

to-purpose transition of work to shopping. In addition, three of the trips in cell 25 also have this pattern. The morning-to-evening, work-to-shopping pattern between trips one and two therefore represent between 27% and 32% of all three-trip days in the Minneapolis-St. Paul survey.

The second matrix, Figure 4, shows the highest frequency of transitions between trips two to three occurring within time slot six. A secondary pattern also occurs in cell 67 which correlates with the overall three-trip day pattern. In cell 66, 18 transitions out of 23 are from shopping to home; and in cell 67, three out of 11. Therefore, we believe it reasonable to state that the three-trip day pattern represents at least 27% of the three-trip days (18 out of 66 such days), or 3.0% of the complete car-weekdays in the survey.

Table 4 contains the values describing the typical three-trip day pattern. In calculating results for the trips 2A-3A combinations, the total distance of trip 1A is allocated between trips 2A and 3A in proportion to the mean distances of shopping trips and home trips in time slot six.

The distribution of trip purposes and trip segment strings in time slot six shows a high degree of correlation between shopping trips and the nonfreeway only segment structure. There are 168 trips in this category but the "expected" frequency is only 134. In this case the expected frequency is obtained by dividing the total number of shopping trips in time slot six according to the division of all trips in time slot six between the freeway and nonfreeway configurations. As a consequence of the correlation between shopping trips and the nonfreeway trip structure, we believe that the destination for the shopping trip is reached before rather than after the driver enters the freeway portion of his return trip home. Therefore, in allocating the distance between trips 2B and 3B, the first segment of the trip is divided in proportion to the mean distances of nonfreeway shopping trips and the first leg of nonfreeway-freeway-nonfreeway home trips in time slot six. Average speeds shown and used in calculating elapsed time are those of the appropriate trip purpose and time slot. Engine running stops and idle time are assigned in proportion to total trip distance.

TABLE 4

IDS TYPICAL THREE-TRIP DAY PATTERNS

(REPRESENTS 27% OF ALL THREE-TRIP DAYS, 3.0% OF ALL COMPLETE CAR-WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME MEAN	START TIME RANGE*	MEAN ELAPSED TIME (MIN)	DISTANCE (MILES) MEAN	DISTANCE (MILES) RANGE**	AVERAGE SPEED (MPH) MEAN	AVERAGE SPEED (MPH) RANGE**	NUMBER OF STOPS (IDLES) MEAN	NUMBER OF STOPS (IDLES) RANGE**	IDLE TIME (MIN) MEAN	IDLE TIME (MIN) RANGE**
1A	WORK	1	N	0725	0653 - 0757	15.8	6.1	2.0 - 11.0	23.1	15.0 - 30.0	5.6	1.0 - 9.0	0.6	0.0 - 1.0
	OR:													
1B	WORK	1	N	0723	0654 - 0752	6.2	2.9	0.1 - 5.0	28.0	10.0 - 40.0	2.6	0.0 - 5.0	0.2	0.0 - 1.0
		2	F			10.9	7.5	1.0 - 10.0	41.3	30.0 - 55.0	0.3	0.0 - 1.0	0.0	0.0 - 1.0
		3	N			8.1	3.8	0.1 - 6.0	28.0	15.0 - 50.0	2.8	0.0 - 6.0	0.2	0.0 - 1.0
						25.2	14.2				5.7		0.4	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 3 TO 2 RESPECTIVELY														
2A	SHOP	1	N	1725	1648 - 1802	5.6	2.3	1.0 - 4.0	24.5	10.0 - 35.0	2.6	0.0 - 5.0	0.1	0.0 - 1.0
3A	HOME	1	N	1754	----------	9.9	3.8	1.0 - 7.0	23.1	15.0 - 40.0	3.5	0.0 - 8.0	0.3	0.0 - 1.0
	OR:													
2B	SHOP	1	N	1725	1648 - 1802	4.5	1.8	0.1 - 3.0	24.5	10.0 - 35.0	2.0	0.0 - 5.0	0.1	0.0 - 1.0
3B	HOME	1	N	1753	----------	4.0	2.0	0.1 - 3.0	29.9	15.0 - 45.0	1.8	0.0 - 3.0	0.2	0.0 - 1.0
		2	F			10.7	7.5	1.0 - 10.0	42.1	25.0 - 55.0	0.5	0.0 - 1.0	0.0	0.0 - 1.0
		3	N			5.5	2.9	0.1 - 6.0	31.7	15.0 - 50.0	2.2	0.0 - 5.0	0.2	0.0 - 1.0
						20.2	12.4				4.5		0.4	
TRIP COMBINATIONS 2A-3A AND 2B-3B OCCUR IN THE RATIO OF 3 TO 2 RESPECTIVELY														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

The Four-Trip Day

Figures 5 through 7 show the three trip-to-trip transition matrices for the four-trip day. Two typical patterns for the four-trip day were discovered: The first is distinguished by a pair of trips in the evening, the second by a pair of trips during the noon period.

Evening Patterns

Cell 26 in Figure 5 shows that 70 cars transitioned from time slot two to time slot six. Of these, 62 transitioned from a work trip to a home trip. Turning to Figure 6, we see that these 62 cars were among the 74 cars that transitioned to a third trip in time slots six and seven. These 74 transitions included 38 home-to-shopping trips. Figure 7 shows that third trips in time slot six transitoned primarily to fourth trips in time slots six and seven. Third trips in time slot seven transitioned to time slots seven and eight. Of the 16 of these fourth trips in time slot six (cell 66), 13 were return trips from shopping. Of the 45 fourth trips in time slot seven (cells 67 and 77), 29 were return trips from shopping.

From these data we deduce the typical Four-Trip Day (Evening) Pattern, shown in Table 5. Trip one is to work in time slot two. Trip two returns home in time slot six. Trip three is a shopping trip in time slot six or seven. Trip four returns home in time slot seven. Trips one and two are divided between the two-trip segment structures used in the previous two patterns in the same two-to-one ratio. The trip segment structures of the evening trips are all nonfreeway trips.

The minimum number of car-days that show the typical four-trip evening pattern (using the number of home-to-shop or recreation trips in cells 66 and 67 of Figure 6) is 38. This represents 31% of all four-trip days and 6.4% of all car-weekdays in the survey.

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	1	0	0	0	0	1	0	0
0600-0859	3	5	15 W-Lunch	20 W-H	70 W-H	0	0	
0900-1129	2	1	0	1	0	0	0	
1130-1329	0	1	0	0	0	0		
1330-1629	0	1	0	0	0			
1630-1829	3	0	0	0				
1830-2059	0	0	0					
2100-2359	0	0						

TRIP ONE TO TRIP TWO

TOTAL FOUR-TRIP WEEKDAYS: 124

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 5

FOUR-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	1	0	0	0
0600-0859	0	0	1	0	2	0	0	0
0900-1129	1	4	1	1	0	0	0	0
1130-1329	9 Lunch-W	3	2	1	1	0	0	0
1330-1629	7	6	8	0	0	0	0	0
1630-1829	38 H-S H-R	36 H-S H-R	2	0	0	0	0	0
1830-2059	0	0	0	0	0	0	0	0
2100-2359	0	0	0	0	0	0	0	0

TRIP TWO TO TRIP THREE

TOTAL FOUR-TRIP WEEKDAYS: 124

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 6

FOUR-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859	0	0	0	0	0	0	0	0
0900-1129	0	0	0	1	0	0	0	0
1130-1329	1	1	12 W-H	0	0	0	0	0
1330-1629	5	7	0	0	0	0	0	0
1630-1829	16 S-H	22 S-H R-H	11 W-H R-H	0	0	0	0	0
1830-2059	26 S-H R-H	19 R-H S-H	3	0	0	0	0	0
2100-2359	0	0	0	0	0	0	0	0

TRIP THREE TO TRIP FOUR

TOTAL FOUR-TRIP WEEKDAYS: 124

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 7

FOUR-TRIP WEEKDAY TRANSITION MATRIX

TABLE 5

THE TYPICAL FOUR-TRIP DAY (EVENING) PATTERN

(REPRESENTS 31% OF ALL FOUR-TRIP DAYS, 6.4% OF ALL COMPLETE CAR-WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME MEAN	START TIME RANGE*	MEAN ELAPSED TIME (MIN)	DISTANCE (MILES) MEAN	DISTANCE (MILES) RANGE**	AVERAGE SPEED (MPH) MEAN	AVERAGE SPEED (MPH) RANGE**	NUMBER OF STOPS (IDLES) MEAN	NUMBER OF STOPS (IDLES) RANGE**	IDLE TIME (MIN) MEAN	IDLE TIME (MIN) RANGE**
1A	WORK	1	N	0725	0653 - 0759	15.8	6.1	2.0 - 11.0	23.1	15.0 - 40.0	5.6	1.0 - 9.0	0.0	0.0 - 1.0
	OR:													
1B	WORK	1	N	0723	0654 - 0752	6.2	2.9	0.1 - 5.0	28.0	10.0 - 40.0	2.6	0.0 - 4.0	0.2	0.0 - 1.0
		2	F			10.9	7.5	1.0 - 10.0	41.3	30.0 - 55.0	0.3	0.0 - 1.0	0.0	0.0 - 1.0
		3	N			8.1	3.8	0.1 - 6.0	28.0	15.0 - 50.0	2.8	0.0 - 4.0	0.2	0.0 - 1.0
						25.2	14.2				5.7		0.4	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 3 TO 2 RESPECTIVELY														
2A	HOME	1	N	1709	1633 - 1745	15.2	6.1	2.0 - 11.0	24.0	10.0 - 35.0	6.9	0.0 - 10.0	0.4	0.0 - 1.0
	OR:													
2B	HOME	1	N	1658	1624 - 1727	7.6	3.8	0.1 - 5.0	29.9	15.0 - 45.0	3.5	0.0 - 6.0	0.3	0.0 - 1.0
		2	F			10.7	7.5	1.0 - 10.0	42.1	25.0 - 55.0	0.5	0.0 - 1.0	0.0	0.0 - 1.0
		3	N			5.5	2.9	0.1 - 6.0	31.7	15.0 - 50.0	2.2	0.0 - 3.0	0.2	0.0 - 1.0
						23.8	14.2				6.2		0.5	
3	SHOP	1	N	1822	1708 - 1936	7.0	2.8	0.1 - 4.0	24.0	10.0 - 35.0	3.1	2.0 - 6.0	0.3	0.0 - 1.0
4	HOME	1	N	1948	1904 - 2031	8.4	3.3	1.0 - 5.0	23.6	10.0 - 35.0	2.8	1.0 - 5.0	0.1	0.0 - 1.0

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

Noon Patterns

Cell 24 in Figure 5 shows 15 cars transitioning from a trip in time slot two to a trip in time slot four. Twelve of them transition from a first trip to work, five to a home trip, three of them to a shopping trip, and three to a business trip. Under the definition of trip purpose given to survey participants, any of these trips could be to lunch. In Figure 6, cell 44 shows nine trip twos transitioning to trip threes in time slot four. Eight of these are return trips to work, five from home and three from shopping. Cell 45 shows seven trip twos transitioning to trip threes between time slots four and five. Two of these are return trips to work from business.

Cell 46 of Figure 7 shows that twelve third trips in time slot four transition to a fourth trip in time slot six. Ten of these are from work to home. In addition, cell 56 shows seven third trips that transition to fourth trips between time slot five and six. Four of these are from work to home. These data indicate the structure of the typical Four-Trip (Noon) Pattern: trip one is to work, trip two to lunch, trip three back to work, and trip four home in the evening.

The noontime trips are both nonfreeway. The values in Table 6 are obtained by combining and weighting the computed values for the three principal purposes: home, business and shopping. The morning work trip and the evening return home trip have the same structure as in the other typical patterns and are weighted in the same way.

The minimum number of car-days that showed the Four-Trip Day (Noon) Pattern was ten. This number represents 8% of all four-trip days and 1.8% of all car-days in the sample.

TABLE 6

THE TYPICAL FOUR-TRIP DAY (NOON) PATTERN

(REPRESENTS 8% OF ALL FOUR-TRIP DAYS, 1.8% OF ALL COMPLETE CAR-WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	N	0725	0653 - 0757	15.8	6.1	2.0 - 11.0	23.1	15.0 - 40.0	5.6	1.0 - 9.0	0.0	0.0 - 1.0
	OR:													
1B	WORK	1	N	0723	0654 - 0752	6.2	2.9	0.1 - 5.0	28.0	10.0 - 40.0	2.6	0.0 - 6.0	0.2	0.0 - 1.0
		2	F			10.9	7.5	1.0 - 10.0	41.3	30.0 - 55.0	0.3	0.0 - 1.0	0.0	0.0 - 1.0
		3	N			8.1	3.8	0.1 - 6.0	28.0	15.0 - 50.0	2.8	0.0 - 5.0	0.2	0.0 - 1.0
						25.2	14.2				5.7		0.4	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 3 TO 2 RESPECTIVELY														
2	H,B,S (Lunch)	1	N	1214	1144 - 1244	6.5	2.7	1.0 - 4.0	24.9	10.0 - 40.0	3.1	0.0 - 5.0	0.1	0.0 - 1.0
3	WORK	1	N	1226	1159 - 1253	6.1	2.5	0.1 - 4.0	24.6	10.0 - 35.0	2.8	1.0 - 5.0	0.0	0.0 - 1.0
4A	HOME	1	N	1709	1633 - 1745	15.2	6.1	2.0 - 11.0	24.0	10.0 - 35.0	6.9	0.0 - 10.0	0.4	0.0 - 1.0
	OR:													
4B	HOME	1	N	1658	1629 - 1729	7.6	3.8	0.1 - 5.0	29.9	15.0 - 45.0	3.5	0.0 - 6.0	0.3	0.0 - 1.0
		2	F			10.7	7.5	1.0 - 10.0	42.1	25.0 - 55.0	0.5	0.0 - 1.0	0.0	0.0 - 1.0
		3	N			5.5	2.9	0.1 - 6.0	31.7	15.0 - 50.0	2.2	0.0 - 5.0	0.2	0.0 - 1.0
						23.8	14.2				6.2		0.5	

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

The Five-Trip Day

Figures 8 through 11 contain the trip-to-trip transition matrices for the five-trip day. As noted earlier, as the number of trips per day increases, the number of possible trip-to-trip combinations increases geometrically and the likelihood of detecting a typical pattern decreases. The matrices for the five-trip day require careful study of both time slot and purpose transitions to detect the typical pattern that is present.

Of the 33 transitions in cell 26 of Figure 8, 20 are from work trips in time slot two to home trips in time slot six. Six of the 14 transitions in the adjacent cell 25 have a similar purpose-to-purpose pattern. In Figure 9, 17 of the 33 transitions in cells 66 and 67 are from home to shopping or recreation. Of the 35 trip three to trip four transitions in cells 67 and 77 of Figure 10, 19 are between various combinations of shopping and recreation. Finally, in Figure 11, 29 of the 36 transitions in cells 67 and 77 are from shopping, school or recreation to home.

From these transitions we deduce the Five-Trip Pattern. A first trip to work in time slot two, a return trip home in time slot six, a shopping or recreation trip in time slot six or seven followed by another in time slot seven, and finally a return home in time slot seven.

The minumum number of cars that followed this pattern in Minneapolis-St. Paul was 17 (using the number that transitioned from a second trip home in time slot six to a third trip for shopping or recreation in time slot six or seven). This figure represents 24% of all the five-trip days and 2.9% of all the complete car-weekdays in the Minneapolis-St. Paul survey.

Table 7 contains the description of the trips that make up the Five-Trip Day.

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	2	2	0	0	0	0	0	0
0600-0859	1	1	13 W-Lunch	14 W-H	33 W-H W-S	0	0	
0900-1129	1	0	0	0	0	0		
1130-1329	0	0	0	0	0			
1330-1629	1	0	0	0				
1630-1829	0	2	0					
1830-2059	0	0						
2100-2359	0							

TRIP ONE TO TRIP TWO

TOTAL FIVE-TRIP WEEKDAYS: 70

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 8

FIVE-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	1	0	0	1	0	0	0
0600-0859	0	0	0	0	3	0	0	
0900-1129	1	0	0	0	1	0		
1130-1329	10 Lunch-W	1	2	0	0			
1330-1629	3	9	3	0				
1630-1829	22 H-S H-R S-H	11 H-S	0					
1830-2059	2	0						
2100-2359	0							

TRIP TWO TO TRIP THREE
TOTAL FIVE-TRIP WEEKDAYS: 70

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 9

FIVE-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859	0	0	0	0	0	1	0	0
0900-1129	0	1	0	0	0	0	0	0
1130-1329	2	1	6	1	0			
1330-1629	1	4	0	0				
1630-1829	16 H-S S-R	19 H-S R-R R-S	1					
1830-2059	16 S-S R-R	1						
2100-2359	0							

TRIP THREE TO TRIP FOUR
TOTAL FIVE-TRIP WEEKDAYS: 70

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 10

FIVE-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859	0	0	0	0	0	0	0	0
0900-1129	0	0	0	0	0	0	0	0
1130-1329	0	1	2	0	0	0	0	0
1330-1629	0	1	1	0	0	0	0	0
1630-1829	11 S-H	12 R-H S-H	4	0	0	0	0	0
1830-2059	24 S-H R-H	12 S-H R-H	0	0	0	0	0	0
2100-2359	2	0	0	0	0	0	0	0

TRIP FOUR TO TRIP FIVE

TOTAL FIVE-TRIP WEEKDAYS: 70

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 11

FIVE-TRIP WEEKDAY TRANSITION MATRIX

TABLE 7

THE TYPICAL FIVE-TRIP DAY PATTERN

(REPRESENTS 24% OF ALL FIVE-TRIP DAYS, 2.9% OF ALL COMPLETE CAR-WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME MEAN	START TIME RANGE*	MEAN ELAPSED TIME (MIN)	DISTANCE (MILES) MEAN	DISTANCE (MILES) RANGE**	AVERAGE SPEED (MPH) MEAN	AVERAGE SPEED (MPH) RANGE**	NUMBER OF STOPS (IDLES) MEAN	NUMBER OF STOPS (IDLES) RANGE**	IDLE TIME (MIN) MEAN	IDLE TIME (MIN) RANGE**
1A	WORK	1	N	0725	0653 - 0757	15.8	6.1	2.0 - 11.0	23.1	15.0 - 40.0	5.6	1.0 - 9.0	0.0	0.0 - 1.0
	OR:													
1B	WORK	1	N	0723	0654 - 0752	6.2	2.9	0.1 - 5.0	28.0	10.0 - 40.0	2.6	0.0 - 4.0	0.2	0.0 - 1.0
		2	F			10.9	7.5	1.0 - 10.0	41.3	30.0 - 55.0	0.3	0.0 - 1.0	0.0	0.0 - 1.0
		3	N			8.1	3.8	0.1 - 6.0	28.0	15.0 - 50.0	2.8	0.0 - 4.0	0.2	0.0 - 1.0
						25.2	14.2				5.7		0.4	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 3 TO 2 RESPECTIVELY														
2A	HOME	1	N	1709	1633 - 1745	15.2	6.1	2.0 - 11.0	24.0	10.0 - 35.0	2.8	1.0 - 5.0	0.4	0.0 - 1.0
	OR:													
2B	HOME	1	N	1658	1629 - 1727	7.6	3.8	0.1 - 5.0	29.9	15.0 - 45.0	3.5	0.0 - 6.0	0.3	0.0 - 1.0
		2	F			10.7	7.5	1.0 - 10.0	42.1	25.0 - 55.0	0.5	0.0 - 1.0	0.0	0.0 - 1.0
		2	N			5.5	2.9	0.1 - 6.0	31.7	15.0 - 50.0	2.2	0.0 - 3.0	0.2	0.0 - 1.0
						23.8	14.2				6.2		0.5	
3	S OR R	1	N	1827	1714 - 1940	7.5	3.0	0.1 - 5.0	24.0	10.0 - 35.0	3.3	1.0 - 5.0	0.2	0.0 - 1.0
4	S OR R	1	N	1932	1854 - 2010	7.4	2.8	0.1 - 5.0	22.8	10.0 - 35.0	2.9	1.0 - 5.0	0.2	0.0 - 1.0
5	HOME	1	N	1948	1904 - 2031	8.4	3.3	1.0 - 5.0	23.6	10.0 - 35.0	2.8	1.0 - 5.0	0.1	0.0 - 1.0

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

GENERAL RESULTS

This section contains a discussion of additional results for the study including a description of the sample, an analysis of daily variations in the data, and an analysis of the individual trip and segment variables as they are affected by such factors as time of day, trip purpose, and type of route used.

The Minneapolis-St. Paul Sample

During the Minneapolis-St. Paul survey, SDC installed Tachographs in 125 automobiles. For various reasons, described more fully in the Appendix to this report, data from seven of these installations were totally unusable. The results of this study, then, are based on data from 118 automobiles driven in the Minneapolis-St. Paul metropolitan area during the period June 6, 1969 to July 3, 1969. A total of 826 complete car-days are included in the sample. During these days, participating drivers completed 3687 trips, 2704 on weekdays and 983 on weekend days. The average trip generation rate was 4.5 trips per day. Participants drove in excess of 27,000 miles during the survey, an average of 33.3 miles per day. Time spent driving by the average participant amounted to one hour and 10 minutes per day.

Sample Biases

As discussed in Volume 0, Part II of this report, the method used in selecting survey participants biased the sample toward working members of the overall population. In view of this bias, SDC expected that work-related trips would constitute a major component of the resultant typical trip patterns described in the previous section. There is no doubt in our minds that such work-related utilization represents a major, if not the major, component of the overall utilization pattern in the Minneapolis-St. Paul urban area. The sample was made up of participants from all levels of the corporate structure within the participating firms, and the firms represented a reasonable cross-section, in terms of size, of all firms in the area. The results of the survey, therefore, represent a good cross-section of driving behavior within the industrial and commercial sector of the community.

A second bias which has been suggested is that the cars which participated in the survey, being primarily used for transportation to and from work, were not the types of cars people would use for extended trips on weekends or holidays. This would, according to those supporting this theory, explain the somewhat low incidence of long trips and the increased number of zero-trip days on weekends. This argument is bolstered by the fact that SDC chose to exclude station wagons, campers, and pickup trucks from the survey because of certain difficulties inherent in the installation of Tachographs in these vehicles. In the case of Minneapolis-St. Paul, this argument is somewhat further strengthened by the fact that the trip generation rate of all cars was practically the same on both weekdays and weekend days (4.6 trips per weekday, 4.2 trips per weekend day), the trip generation rates for days actually driven (i.e., excluding zero-trip days) was higher for weekend days than for weekdays (5.4 trips per day vs. 4.8 trips per day).

The logistics involved in installing Tachographs in the survey cars required a correction in the survey results to compensate for inconsistencies in the data. The instruments were installed during the morning and afternoon of the first survey day for each car. They were removed during the morning of the eighth day. As a result, the data collected during each car's week represented eight calendar days, but the first and eighth days each contained only about a half-day's worth of data. In order to remove this "half-day" bias which would certainly affect the daily pattern of automobile usage reflected in the results of the survey, data from the last half of the first day and from the first half of the eighth day were combined during the data reduction process. In no case was there an overlap of trips on the two combined days that would cause the loss of a trip in the final results. In Minneapolis-St. Paul there were also no cases in which data from one of the two days was unusable for one reason or another (failure of the Tachograph, errors in the recorded data, etc.).

Data Collected

The Tachograph instrument provided data indicating the day of the survey, trip and trip segment[1] start times and complete times, trip and segment distance traveled, length of periods of idling time in excess of 40 seconds, number of momentary stops, and type of road (freeway, nonfreeway) traveled for each segment. Information contained in the log book kept by the driver indicated the date, the purpose of each trip, geographic zone within which each trip started, type of location from which each trip started, road conditions, driver sex and age, whether the car was parked indoors or out at the end of each trip, and the fuel gauge reading at the start of each day. To these data we added various identifying and categorizing variables during the data reduction process so that the final record on each trip contains at least 54 separate data items.

Daily Patterns

Two classifications of the survey data were made in the analysis. First, data were segregated into two groups by weekday and weekend day. The latter included only Saturday and Sunday. Second, the data were segregated into seven groups by day of the week. The latter was done at the request of CRC[2] to enable an examination of any daily variation that may occur.

The data base of the Minneapolis-St. Paul survey contains 560 active car-weekdays and 181 active car-weekend days. To these sums must be added zero-trip days that occurred but are not contained in the data base: 30 car-weekdays and 55 car-weekend days. The resulting totals are 590 car-weekdays and 236 car-weekend days. Table 8 shows the daily breakdown of the sample into active and inactive car days.

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[1] A trip segment is defined as that portion of a trip driven over a single type of road, either freeway or nonfreeway.

[2] CRC-APRAC Project Groups CAPE-5 and CAPE-10.

TABLE 8

DAILY SAMPLE SIZE IN CAR-DAYS

DAY	NUMBER OF CAR-DAYS IN SAMPLE		
	ACTIVE	INACTIVE (0-TRIP)	TOTAL
MONDAY	108	10	118
TUESDAY	110	8	118
WEDNESDAY	113	5	118
THURSDAY	115	3	118
FRIDAY	114	4	118
SATURDAY	97	21	118
SUNDAY	84	34	118

During the survey period, participants drove 3687 valid trips. These were divided into 2704 weekday trips and 983 weekend trips. Tables 9 and 10 show the daily distribution by time slot of these trips as well as the weekday and weekend total distributions. Figure 12 presents a more detailed time distribution of weekday trip start times by 15-minute intervals. Figure 13 presents similar data for weekend trip start times.

Trip generation rates for active weekdays are 4.83 trips driven per day (i.e., including only those days on which trips were actually taken) and 4.58 trips per day for all days (i.e., including zero-trip days). On weekends, these rates are 5.43 and 4.16 trips per day respectively. The larger difference between the last two numbers reflects the greater likelihood of a zero-trip day on a Saturday or Sunday.

An analytical tool that assisted greatly in determining trip pattern relationships is the trip-to-trip transition matrix. It is a tableau showing the incidence of various trip-related dependencies between successive trips. In order to examine weekday-weekend and daily variations, summary two-step,

TABLE 9

TIME DISTRIBUTION OF WEEKDAY
TRIPS BY DAY AND TIME SLOT

DAY	TIME SLOT								
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	DAILY TOTAL
MONDAY	4	106	15	44	52	159	114	40	534
TUESDAY	4	104	19	43	52	149	108	26	505
WEDNESDAY	9	111	22	46	56	150	105	44	543
THURSDAY	8	103	37	50	67	151	121	34	571
FRIDAY	3	114	22	57	65	147	104	39	551
WEEKDAY TOTAL	28	538	115	240	292	756	552	183	2704

TABLE 10

TIME DISTRIBUTION OF WEEKEND
TRIPS BY DAY AND TIME SLOT

DAY	TIME SLOT						
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	DAILY TOTAL
SATURDAY	45	82	132	235	67	32	593
SUNDAY	37	71	47	140	67	28	390
WEEKEND TOTAL	82	153	179	375	134	60	983

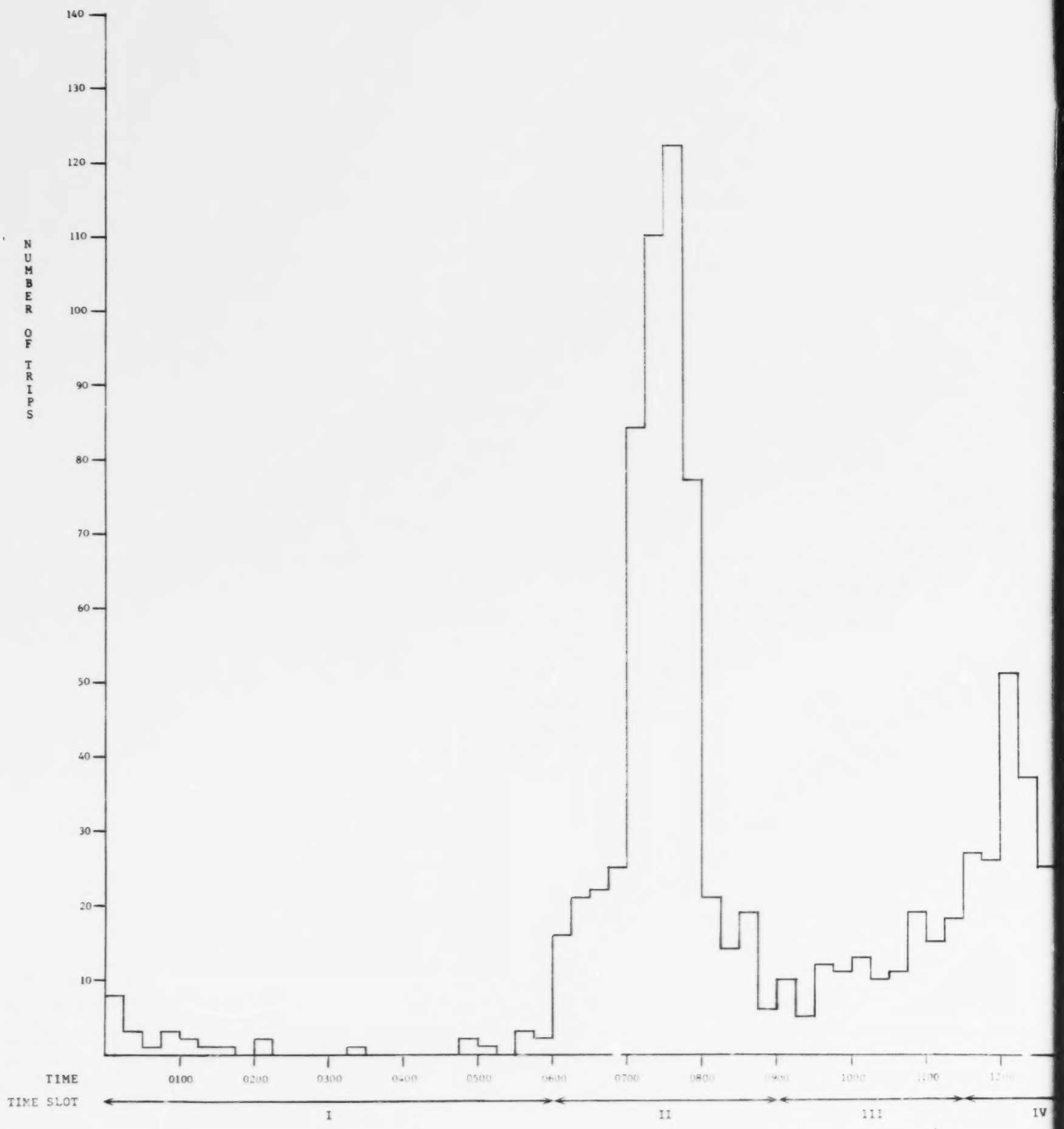
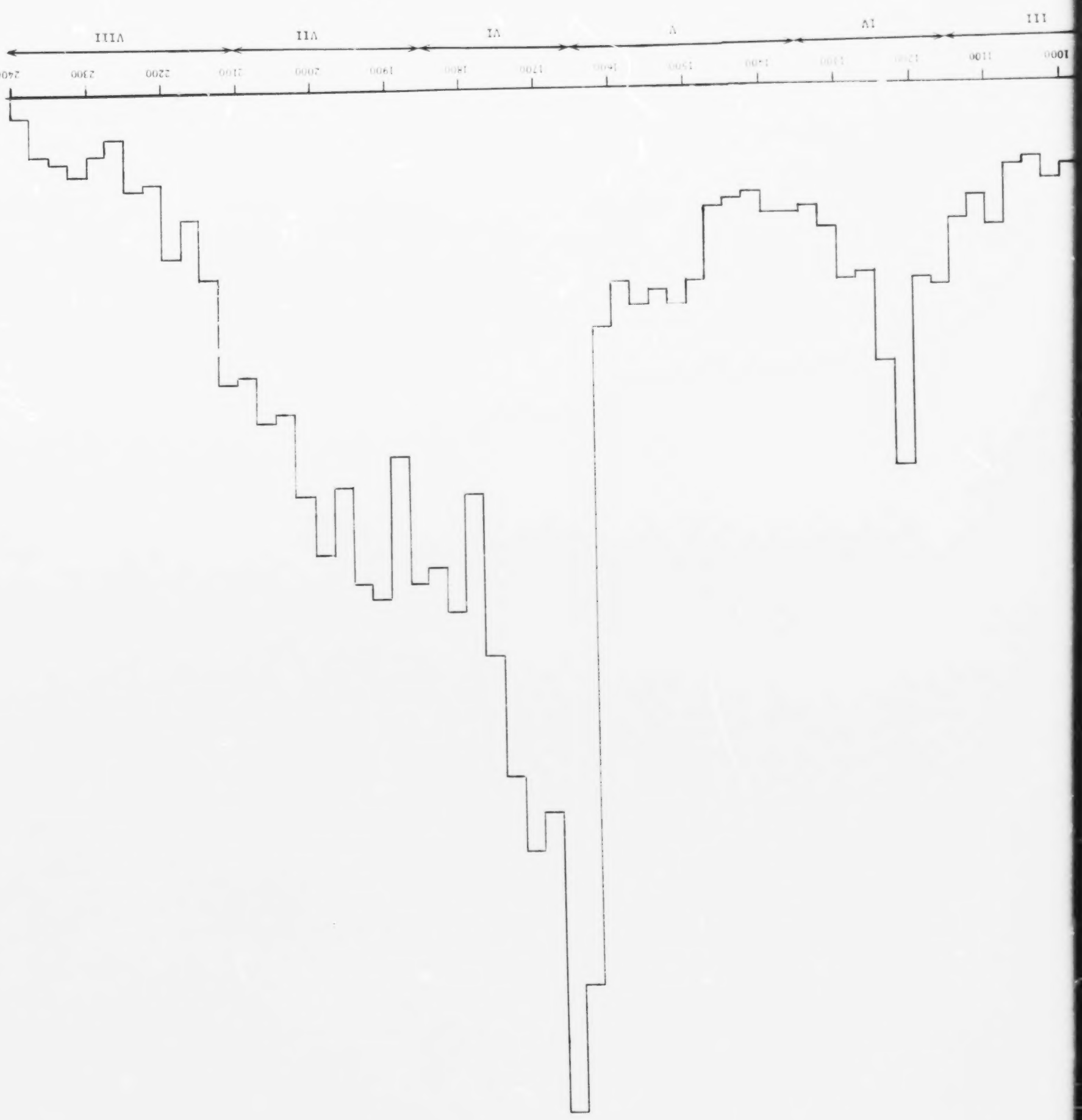


FIGURE 12

DISTRIBUTION OF WEEKDAY TRIP START TIMES


III
IV
V
VI
VII
VIII
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

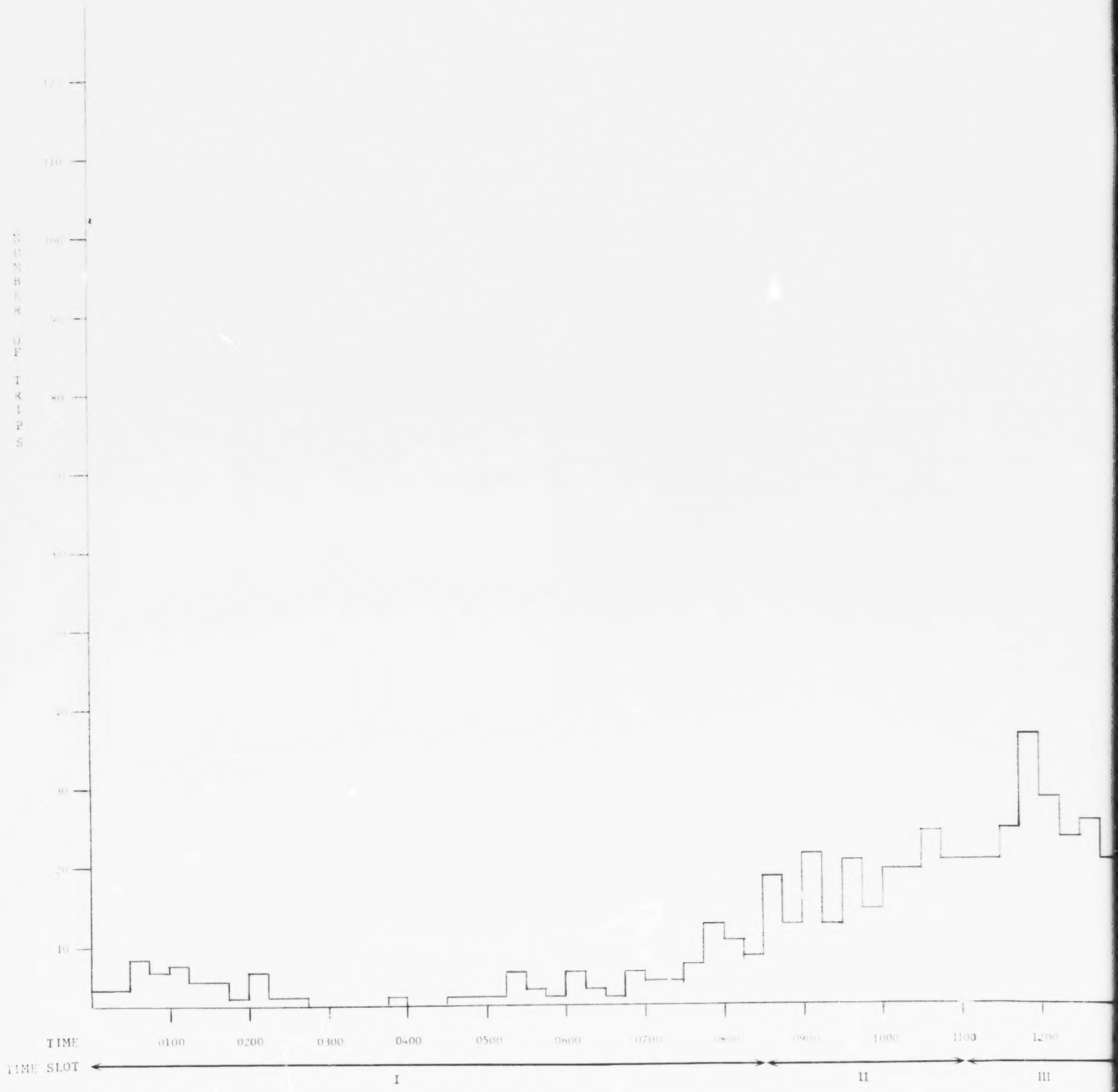
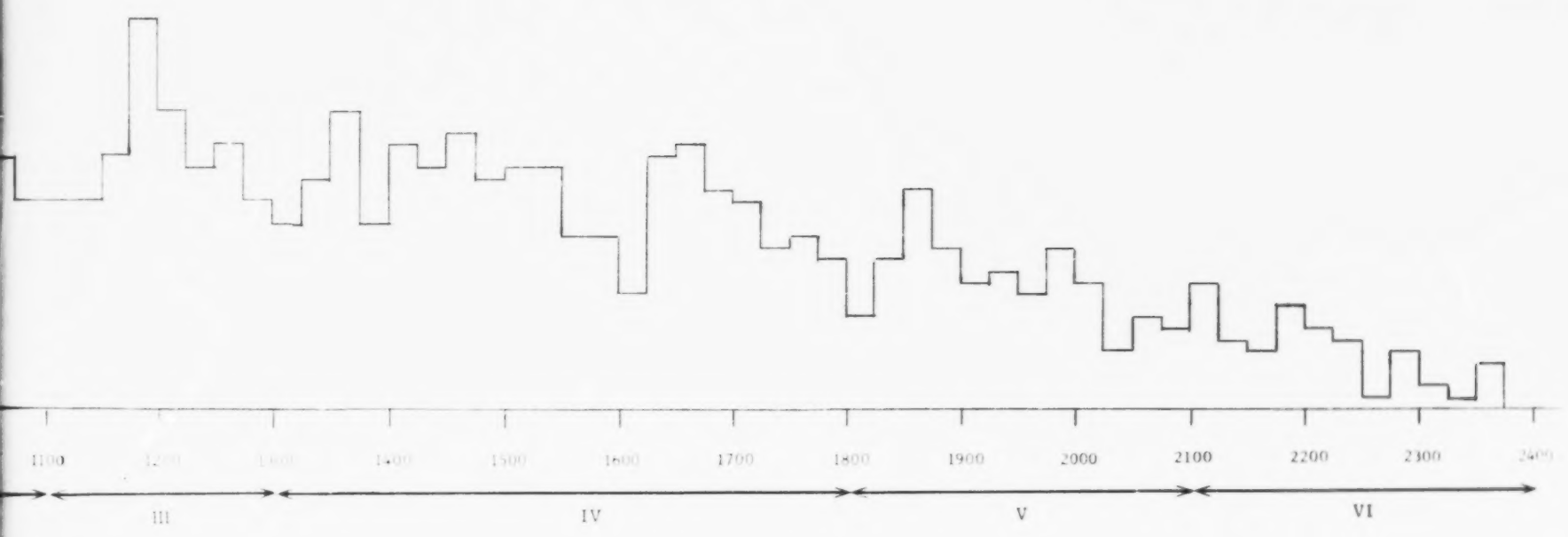


FIGURE 13

DISTRIBUTION OF WEEKEND TRIP START TIMES

B


1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
III
IV
V
VI

B

trip-to-trip transition matrices were assembled for all trips. Figures 14 and 15 are simplified versions of these matrices. The weekday matrix, of which only the upper right-hand triangle is shown, is divided into nine rows and eight columns. Rows two through nine and columns one through eight correspond to the eight weekday time slots. The first row is called the zero row and corresponds to any time slot on the previous day. A trip in the $j^{\underline{th}}$ time slot of any weekday that was preceded by a trip in the $i^{\underline{th}}$ time slot is tabulated in cell ij where i denotes the row and j denotes the column of the transition matrix. If a previous trip took place on the preceding day, the trip is tabulated in zero row in the column appropriate to its own time slot. In the original matrix, the purpose-to-purpose transition is also shown. We have simplified the matrix in Figure 14 by showing only the modal or typical purpose pattern(s) in cells that have high frequency counts. Figure 15 shows the matrix for weekend trips. This matrix is a seven-by-six matrix due to the reduced number of time slots on weekends. The literal coded entries in certain cells indicate purpose-to-purpose transitions that clearly stand out as typifying the particular time slot transition.

A final analytical tool used to evaluate daily variation in trip patterns is a two-way contingency table showing the incidence of particular trip purpose and trip segment string combinations in each time slot. These tables were prepared for weekday, weekend, and daily breakdowns of the data. Chi-square tableaux were prepared for each of these tables to see which purpose stood out as typical for each time slot. In these tableaux, an "expected" frequency count is compiled for each cell by reallocating each column total over the cells in that column in proportion to the row totals. The assumption behind this computation is that row and column effects do not interact to affect the cell totals. In the case at hand, it is clear that these effects do interact (e.g., there is more likelihood of a go-to-work trip being taken in time slot two than in time slot eight). Because there is interaction, the differences between the actual cell counts and the "expected" cell counts obtained by

FROM TIME SLOT \ TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
PREVIOUS DAY		20	478 H-W	19	6	6	7	4	0
0000-0559		8	14	2	0	3	1	0	0
0600-0859			44	44	79 S-S W-H W-S W-B	80 W-H W-S W-B	275 W-H W-S	6	1
0900-1129				50 B-B	43 B-B	9	8	2	1
1130-1329					111 S-W S-S	68 W-H	51 W-H	4	2
1330-1629						118 S-H H-S	112 H-S S-H H-R	24	3
1630-1829							288 S-H H-S H-R S-S	246 H-S S-H R-H H-R	31
1830-2059								265 S-H R-H H-S H-R	104 R-H S-H
2100-2359									41

TOTAL WEEKDAY TRIPS: 2,084

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 14

TWO-STEP TRIP-TO-TRIP

TRANSITION MATRIX, ALL WEEKDAY TRIPS

FROM TIME SLOT \ TO TIME SLOT		0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359
	PREVIOUS DAY	57 H-S	57 H-S H-C	28	30	9	0
	0000-0829	25	26	11	18	1	0
	0830-1059	70 S-H S-S	62 S-H	14	0	0	
	1100-1259	78 S-H H-S	76 S-H H-S	11	0		
	1300-1759	237 S-H H-S S-S R-H H-B	65 R-H S-H	16			
	1800-2059	48 S-H R-H	28				
	2100-2359	16					

TOTAL WEEKEND TRIPS: 983

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 15

TWO-STEP TRIP-TO-TRIP
TRANSITION MATRIX, ALL WEEKEND TRIPS

computation indicate which purpose or trip segment string (row) is typical of the time slot. Tables 11 and 12 show the purpose-time slot contingency tables for weekday and weekend trips. "Expected" frequency counts for each cell are shown in italics below the actual frequency counts. Within the frequency table, the characteristic purpose(s) for each time slot is indicated by underlining the cell count we consider typical.

An analysis of the individual weekday tables compared to the total weekday table in terms of percentage was carried out using the chi-square test. The purpose of the analysis was to detect any significant daily variation in the time slot distribution of trips or in the purpose distribution. The significance level of 0.95 was used. Results of the test showed that the seven weekdays constituted homogeneous samples with respect to both time slot and purpose distributions.

The time slot distribution of trip segment string is shown in Table 13 for weekday trips and in Table 14 for weekend trips. "Expected" frequencies are again shown in italics. The weekday figures indicate an interesting concentration of freeway utilization in the morning hours when compared to the "expectations." The disparity between actual and "expected" frequencies does not recur to the same extent during the evening rush hour even though there are similarly large numbers of trips that use freeways. No doubt this is indicative of the high likelihood that a trip to or from work will use freeways for part of its completion. During the morning hours, especially in time slot two, trips to work constitute such a major portion of all traffic that anything characteristic of them will dominate the statistics of the period. On weekends the use of freeways is diminished both in frequency and in comparison between actual and "expected" frequency in all but the first time slot.

TABLE 11

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP PURPOSE
BY TIME SLOT FOR WEEKDAY TRIPS
CHARACTERISTIC TIME SLOT PURPOSES UNDERLINED

PURPOSE \ TIME SLOT	I 0000-0559	II 0600-0859	III 0900-1129	IV 1130-1329	V 1330-1629	VI 1630-1829	VII 1830-2059	VIII 2100-2359	TOTALS
GO HOME	13 *10*	13 *199*	24 *42*	39 *89*	117 *108*	425 *280*	237 *204*	132 *67*	1000
GO TO WORK	7 *6*	455 *119*	11 *25*	64 *53*	26 *64*	23 *167*	5 *122*	5 *40*	596
BUSINESS	3 *2*	26 *42*	41 *9*	47 *19*	45 *23*	21 *60*	26 *44*	4 *14*	213
SHOP	2 *6*	36 *115*	27 *25*	74 *51*	70 *62*	191 *161*	164 *117*	12 *39*	576
SCHOOL	1 *0*	6 *8*	4 *2*	6 *4*	3 *4*	5 *11*	12 *8*	3 *3*	40
RECREATION	2 *3*	2 *56*	8 *12*	10 *25*	31 *30*	91 *78*	108 *57*	27 *19*	279
TOTALS	28	538	115	240	292	756	552	183	2704

ACTUAL FREQUENCY
"EXPECTED" FREQUENCY (IN ITALICS)

TABLE 12

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP PURPOSE
BY TIME SLOT FOR WEEKEND TRIPS
CHARACTERISTIC TIME SLOT PURPOSES UNDERLINED

TIME SLOT / PURPOSE	I 0000-0829	II 0830-1059	III 1100-1259	IV 1300-1759	V 1800-2059	IV 2100-2359	TOTALS
GO HOME	25 *32*	42 *60*	68 *70*	144 *146*	<u>66</u> *52*	<u>39</u> *23*	384
GO TO WORK	<u>10</u> *3*	7 *5*	6 *6*	7 *13*	2 *4*	1 *2*	33
BUSINESS	6 *2*	4 *4*	5 *5*	8 *10*	4 *4*	0 *2*	27
SHOPPING	17 *26*	<u>62</u> *48*	<u>72</u> *56*	122 *117*	28 *42*	6 *19*	307
SCHOOL	6 *3*	21 *5*	2 *6*	2 *13*	3 *5*	1 *2*	35
RECREATION	18 *16*	17 *31*	26 *36*	<u>92</u> *75*	31 *27*	13 *12*	197
TOTALS	82	153	179	375	134	60	983

ACTUAL FREQUENCY
"EXPECTED" FREQUENCY

TABLE 13

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP SEGMENT STRING BY TIME SLOT FOR WEEKDAYS

TRIP SEGMENT STRING	TIME SLOT								TOTALS
	0000-0559	0600-0859	0800-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N	15 81	334 405	92 89	204 [illegible]	232 [illegible]	551 [illegible]	458 [illegible]	133 [illegible]	2019
NFN	12 7	200 147	23 [illegible]	33 [illegible]	56 [illegible]	198 [illegible]	89 [illegible]	47 [illegible]	658
NFNFN	1 [illegible]	4 [illegible]	0 [illegible]	3 [illegible]	4 [illegible]	7	4 [illegible]	2 [illegible]	25
OTHER	0 [illegible]	0 [illegible]	0 [illegible]	0 [illegible]	0	0	1	1 [illegible]	2
TOTALS	28	538	115	240	292	756	552	183	2704

ACTUAL FREQUENCY

"EXPECTED" FREQUENCY

N = NONFREEWAY SEGMENT

F = FREEWAY SEGMENT

TABLE 14

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP SEGMENT STRING BY TIME SLOT FOR WEEKENDS

TRIP SEGMENT STRING	TIME SLOT						TOTALS
	0000-0829	0830-1059	1100-1259	1300-1359	1800-2059	2100-2359	
N	57 [illegible]	121 [illegible]	142 [illegible]	308 [illegible]	97 [illegible]	43 [illegible]	768
NFN	25 [illegible]	28 [illegible]	34 [illegible]	62 [illegible]	32 [illegible]	16 [illegible]	197
NFNFN	0 [illegible]	4 [illegible]	3 [illegible]	5 [illegible]	5 [illegible]	1	18
OTHER	0 [illegible]	0 [illegible]	0 [illegible]	0 [illegible]	0 [illegible]	0 [illegible]	0 [illegible]
TOTALS	82	153	179	375	134	60	983

ACTUAL FREQUENCY

"EXPECTED" FREQUENCY

N = NONFREEWAY SEGMENT

F = FREEWAY SEGMENT

Trip Descriptors

The discussion of general results so far has dealt with the incidence of variables that can only be counted. These variables essentially define cases under which we wish to examine the behavior of such trip-descriptive variables as distance, elapsed time, velocity, number of stops with engine on and off, and idling time. The present section is devoted to a detailed examination of these variables.

Trip and Segment Distance

The average distance per trip driven during the survey was 6.91 miles. This number is deceptive, however. The distribution of trip distances understandably shows a wide range as is indicated in Figure 16, Distribution of Weekday Trip Distance, and in Figure 17, Distribution of Weekend Trip Distance. Of more particular interest is the time distribution of distance with respect to trip segment string. Tables 15 and 16 show the time slot distribution of number of trips by trip segment string for weekday and weekend respectively along with the average trip distance for each type of trip during the time slot. Tables 17 and 18 show the distribution of segment distance by time slot for nonfreeway and freeway segments associated with freeway trips on weekdays and weekend days.

The data in Figures 16 and 17 are arbitrarily cut off above 28 miles. Nevertheless, these figures account for 98.0% of all weekday trips and 96.0% of all weekend trips.

Trip and Segment Velocity

The distribution of trip velocity, as shown in Figure 18 for weekdays and in Figure 19 for weekends, is unimodal in both cases (i.e., single peaked). The weekend distribution is, however, slightly more spread as indicated by its larger standard deviation, 12.0 versus 11.1 for weekday trips.

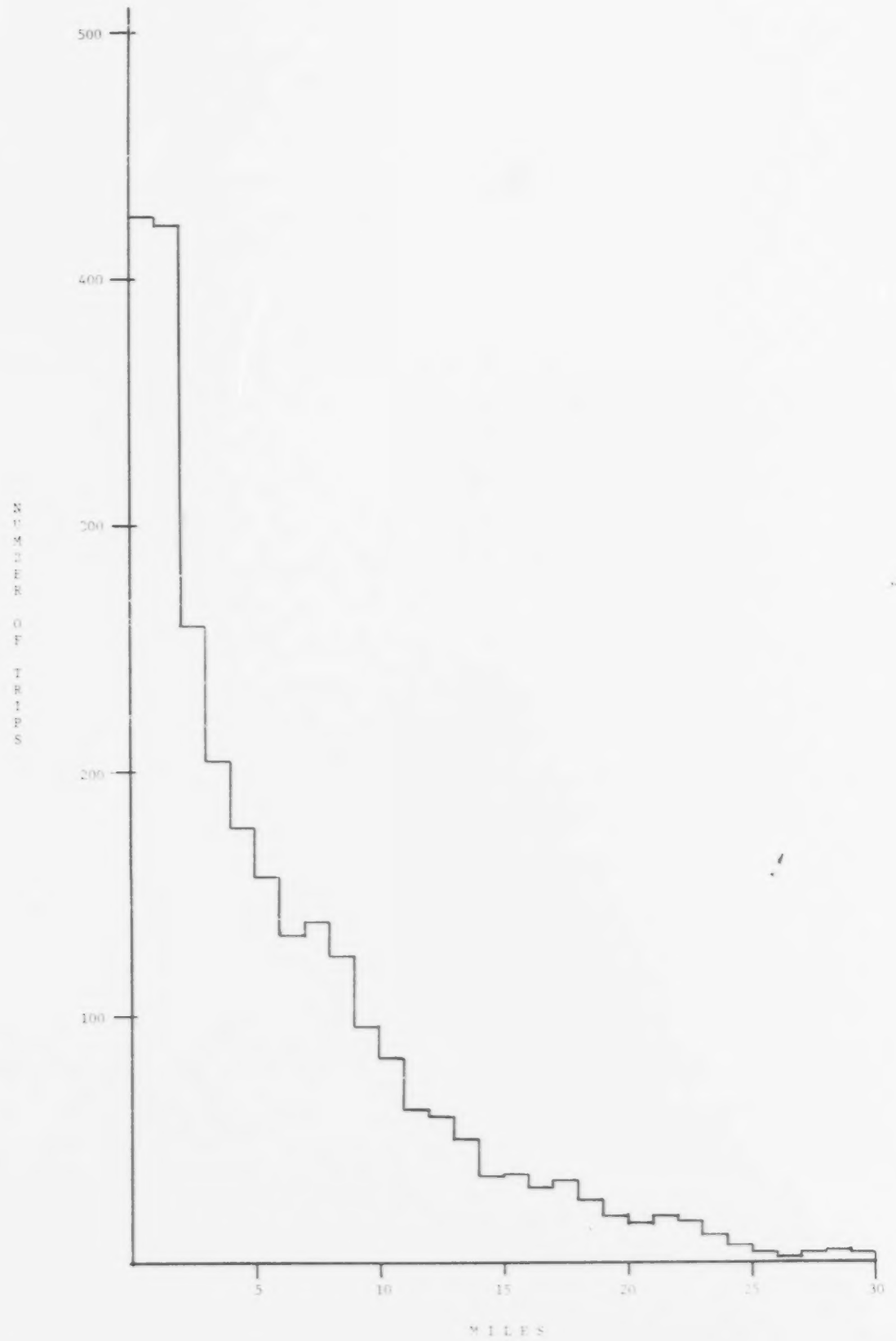


FIGURE 16

DISTRIBUTION OF TRIP DISTANCE, WEEKDAY TRIPS

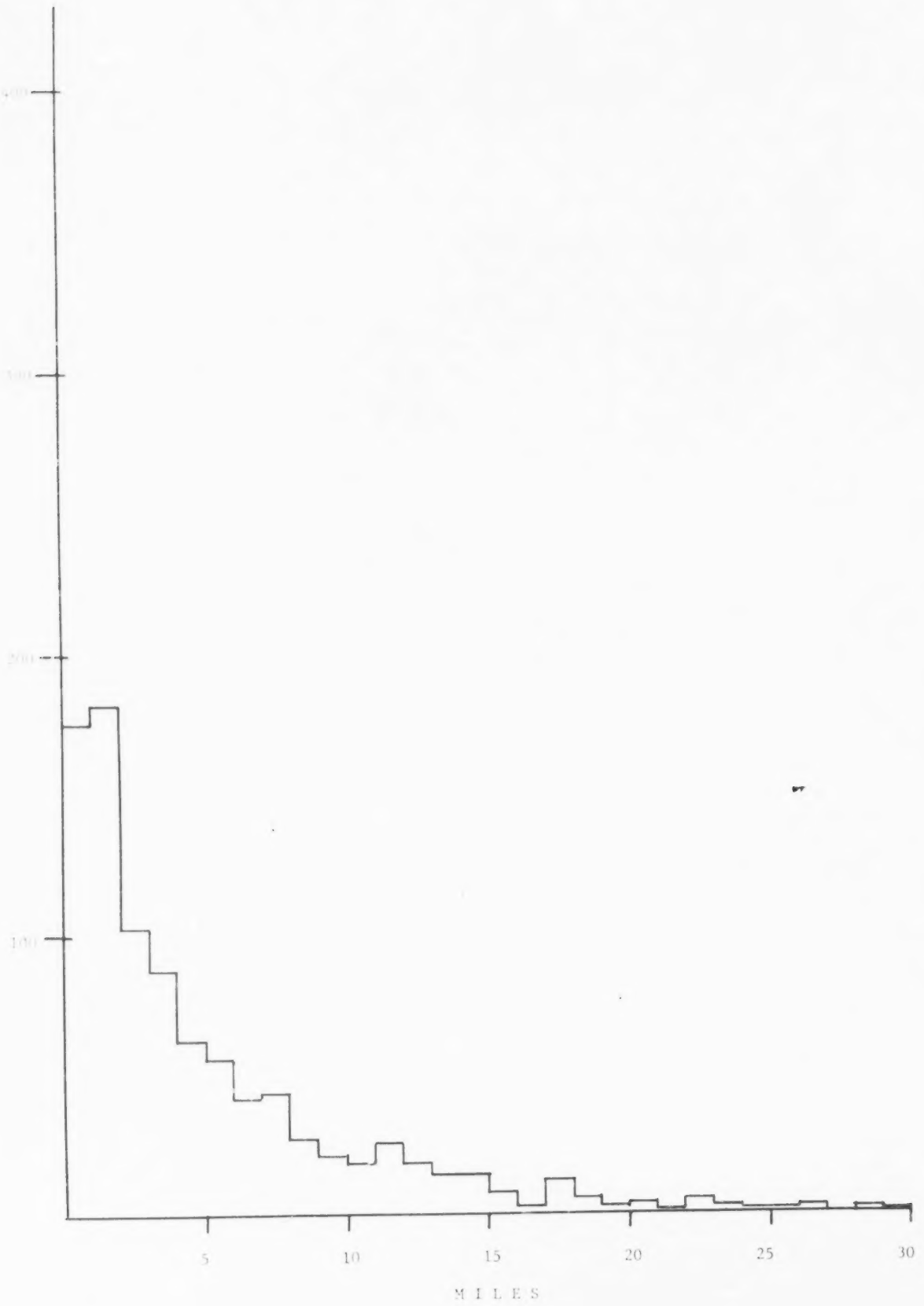


FIGURE 17

DISTRIBUTION OF TRIP DISTANCE, WEEKEND TRIPS

TABLE 15

DISTRIBUTION OF WEEKDAY TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE DISTANCE PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT							TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2129	2130-2359	
N: NUMBER OF CASES	15	334	92	204	232	331	458	133	2019
MEAN DISTANCE (MI.)	5.1	5.9	3.3	2.7	3.5	4.2	3.4	4.3	4.2
NFN: NUMBER OF CASES	12	200	23	33	56	148	80	47	599
MEAN DISTANCE	20.8	14.1	12.5	9.6	13.1	15.0	14.3	13.9	14.3
NFNFN: NUMBER OF CASES	1	4	0	1	4	7	4	2	23
MEAN DISTANCE	18.0	16.5	0	23.6	24.0	24.7	27.2	31.6	24.3
OTHER: NUMBER OF CASES	0	0	0	0	0	0	1	1	2
MEAN DISTANCE	0	0	0	0	0	0	41.0	48.0	91.0
TOTAL: NUMBER OF CASES	28	538	115	240	292	536	543	183	2704
MEAN DISTANCE	12.3	9.0	5.1	4.0	5.6	7.2	5.4	6.3	6.8

TABLE 16

DISTRIBUTION OF WEEKEND TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE DISTANCE PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	57	121	142	308	97	43	768
MEAN DISTANCE (MI.)	5.1	2.9	3.5	3.2	5.6	6.1	3.8
NFN: NUMBER OF CASES	25	28	34	62	32	16	197
MEAN DISTANCE	14.9	10.0	13.1	18.8	23.7	18.3	16.8
NFNFN: NUMBER OF CASES	0	4	3	5	5	1	18
MEAN DISTANCE	0	46.8	41.0	47.5	71.2	23.4	51.3
OTHER: NUMBER OF CASES	0	0	0	0	0	0	0
MEAN DISTANCE	0	0	0	0	0	0	0
TOTAL: NUMBER OF CASES	82	153	179	375	134	60	983
MEAN DISTANCE	8.1	5.3	6.0	6.4	12.4	9.6	7.3

TABLE 17

AVERAGE DISTANCE FOR SEGMENTS OF WEEKDAY
FREEWAY TRIPS BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	27	416	47	75	134	407	198	106	1410
AVERAGE DISTANCE	2.7	3.3	2.6	2.6	3.2	3.4	3.5	3.3	3.3
FREEWAY									
NUMBER OF CASES	14	208	24	38	62	215	100	53	714
AVERAGE DISTANCE	13.9	7.2	7.1	5.4	7.2	8.2	8.8	9.7	7.9
TOTAL									
NUMBER OF CASES	41	624	71	113	196	622	298	159	2124
AVERAGE DISTANCE	6.5	4.6	4.1	3.5	4.5	5.1	5.3	5.4	4.9

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 18

AVERAGE DISTANCE FOR SEGMENTS OF WEEKEND FREEWAY TRIPS
IN MINNEAPOLIS-ST. PAUL SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
NONFREEWAY[1]							
NUMBER OF CASES	50	64	86	138	79	36	453
AVERAGE DISTANCE	2.8	2.2	2.9	3.9	5.1	3.6	3.5
FREEWAY							
NUMBER OF CASES	25	34	42	72	41	19	233
AVERAGE DISTANCE	8.7	7.5	10.0	13.0	18.0	11.4	11.9
TOTAL							
NUMBER OF CASES	75	98	128	210	120	55	686
AVERAGE DISTANCE	4.8	4.0	5.2	7.0	9.5	6.3	6.4

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

FIGURE 18

DISTRIBUTION OF AVERAGE SPEED, WEEKDAY TRIPS

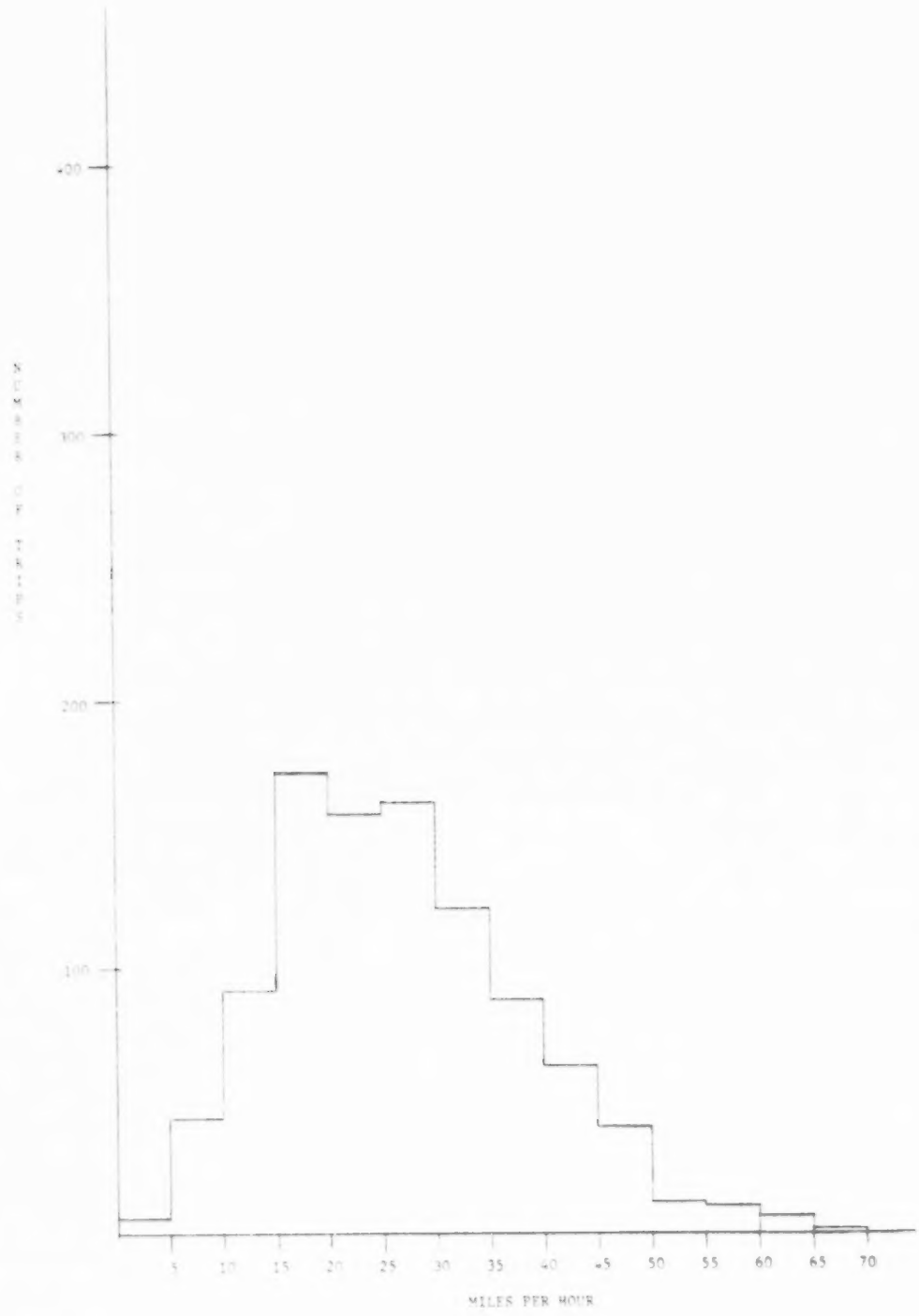


FIGURE 19

DISTRIBUTION OF AVERAGE SPEED, WEEKEND TRIPS

Again, the time and trip segment string distribution points out greater differences. Tables 19 and 20 are analogous to the previous tabular presentation on trip distance. One notices increased average velocities on all freeway-associated trips as compared to the nonfreeway trips, but the degree of increase varies with time slot.

Tables 21 and 22 provide average velocity information on freeway and freeway segments associated with freeway trips by time slot for weekdays and weekends.

Trip and Segment Elapsed Time

The distributions of elapsed time for weekday and weekend trips are shown in Figures 20 and 21 respectively. The mean for weekday trips is 14.2 minutes, for weekend trips it is 13.6 minutes. The weekday distribution indicates that 90% of all trips on these days are completed within 30 minutes. On weekends, this figure drops to 28 minutes.

Tables 23 and 24 show the mean elapsed time by time slot and trip segment string. The dependency of elapsed time on the complexity of the trip segment structure stands out clearly. Tables 25 and 26 present mean segment elapsed time for trips involving the use of freeways on weekdays and weekend days. The large number of short trip times is obviously related to the similar prevalence of short trip distances discussed previously.

Trip and Segment Idling

The present survey measures idling time in terms of two parameters: the number of stops with engine running per trip or segment and the actual idling time accumulated during periods of idling in excess of about 40 seconds. The mean number of stops per trip by time slot and trip segment string is shown in Tables 27 and 28 for weekday and weekend trips. Tables 29 and 30 show the mean number of stops for trip segments of freeway trips on weekdays and weekends.

TABLE 19

DISTRIBUTION OF WEEKDAY TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE SPEED IN MILES PER HOUR PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N: NUMBER OF CASES	15	334	92	204	232	551	458	133	2019
AVERAGE SPEED (MPH)	21.2	22.6	21.6	25.0	20.2	24.4	23.?	22.3	23.1
NFN: NUMBER OF CASES	12	200	23	33	56	198	89	47	658
AVERAGE SPEED	35.8	34.8	36.3	38.8	34.6	35.8	35.7	34.6	35.5
NFNFN: NUMBER OF CASES	1	4	0	3	4	7	4	?	25
AVERAGE SPEED	38.8	33.5	0	42.0	35.4	38.0	30.6	35.?	36.0
OTHER: NUMBER OF CASES	0	0	0	0	0	0	1	1	2
AVERAGE SPEED	0	0	0	0	0	0	29.6	53.3	41.5
TOTAL: NUMBER OF CASES	28	538	115	240	292	756	552	183	2704
AVERAGE SPEED	28.1	27.2	24.5	26.6	23.2	27.5	25.4	25.8	26.2

TABLE 20

DISTRIBUTION OF WEEKEND TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE SPEED IN MILES PER HOUR PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1330-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	57	121	142	308	97	43	768
AVERAGE SPEED (MPH)	24.7	23.9	26.0	22.6	26.7	22.4	24.1
NFN: NUMBER OF CASES	25	28	34	62	32	16	197
AVERAGE SPEED	37.8	36.4	39.0	35.5	38.2	35.3	36.9
NFNFN: NUMBER OF CASES	0	4	3	5	5	1	18
AVERAGE SPEED	0	35.8	43.2	36.8	44.3	26.7	39.2
OTHER: NUMBER OF CASES	0	0	0	0	0	0	0
AVERAGE SPEED	0	0	0	0	0	0	0
TOTAL: NUMBER OF CASES	82	153	179	375	134	60	983
AVERAGE SPEED	28.7	26.5	28.8	24.9	30.1	25.9	26.9

TABLE 21

AVERAGE SPEED FOR SEGMENTS OF WEEKDAY FREEWAY

TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	27	416	47	75	134	407	198	106	1410
AVERAGE SPEED	29.5	30.1	31.6	33.2	29.0	30.9	32.5	30.0	30.8
FREEWAY									
NUMBER OF CASES	14	208	24	38	62	215	100	53	714
AVERAGE SPEED	39.5	42.1	42.6	45.1	44.2	43.0	40.0	39.4	42.2
TOTAL									
NUMBER OF CASES	41	624	71	113	196	622	298	159	2124
AVERAGE SPEED	32.9	34.1	35.3	37.2	33.8	35.1	35.0	33.1	34.6

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I.E., TRIP WITH N-TRIP SEGMENT SEQUENCE)

TABLE 22

AVERAGE SPEEDS FOR SEGMENTS OF WEEKEND FREEWAY
TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
NONFREEWAY[1]							
NUMBER OF CASES	50	64	86	138	79	36	453
AVERAGE SPEED	33.1	29.4	35.4	29.7	34.5	29.3	31.9
FREEWAY							
NUMBER OF CASES	25	34	42	72	41	19	233
AVERAGE SPEED	41.5	43.6	43.3	42.7	46.3	36.3	42.9
TOTAL							
NUMBER OF CASES	75	98	128	210	120	55	686
AVERAGE SPEED	35.9	34.3	38.0	34.2	38.5	31.7	35.6

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

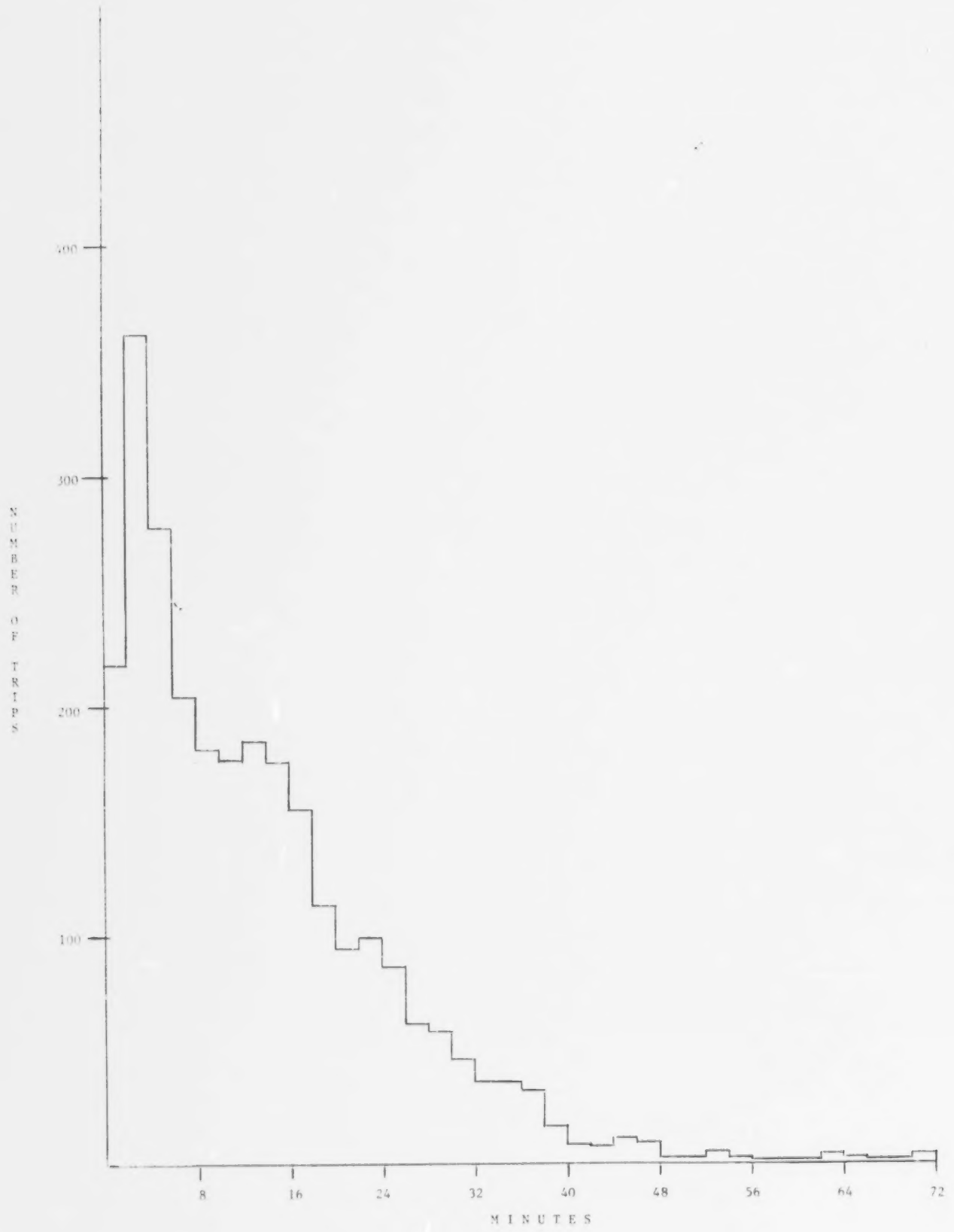


FIGURE 20

DISTRIBUTION OF TRIP TIME, WEEKDAY TRIPS

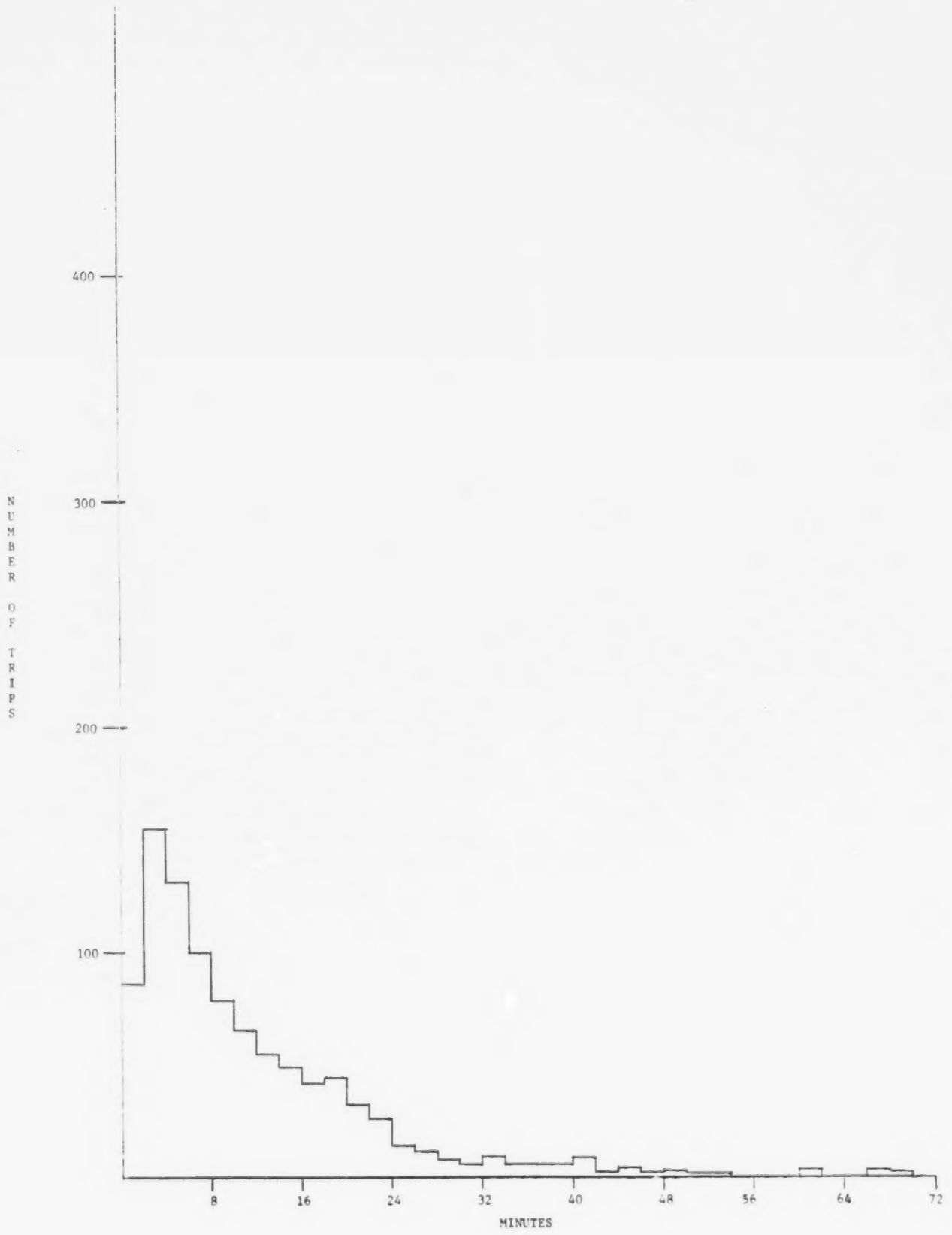


FIGURE 21

DISTRIBUTION OF TRIP TIME, WEEKEND TRIPS

TABLE 23

DISTRIBUTION OF WEEKDAY TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE TRIP ELAPSED TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N: NUMBER OF CASES	15	334	92	204	232	551	458	133	2019
ELAPSED TIME (MIN)	14.7	15.4	9.1	7.2	10.2	11.1	8.7	11.8	10.7
NFN: NUMBER OF CASES	12	200	23	33	56	198	89	47	658
ELAPSED TIME	30.6	24.1	19.9	15.3	22.4	24.9	23.4	24.2	23.6
NFNFN: NUMBER OF CASES	1	4	0	3	4	7	4	2	25
ELAPSED TIME	27.8	29.5	0	36.8	38.6	38.8	53.2	54.9	40.2
OTHER: NUMBER OF CASES	0	0	0	0	0	0	1	1	2
ELAPSED TIME	0	0	0	0	0	0	87.2	156.4	117.3
TOTAL: NUMBER OF CASES	28	538	115	240	292	756	552	183	2704
ELAPSED TIME	22.0	18.7	11.3	8.7	12.9	15.0	11.5	16.2	14.2

TABLE 24

DISTRIBUTION OF WEEKEND TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE TRIP ELAPSED TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	57	121	142	308	97	43	768
ELAPSED TIME (MIN)	12.5	7.2	8.3	8.3	11.1	15.5	9.2
NFN: NUMBER OF CASES	25	28	34	62	32	16	197
ELAPSED TIME	23.3	16.1	19.0	28.0	34.0	27.4	25.1
NFNFN: NUMBER OF CASES	0	4	3	5	5	1	18
ELAPSED TIME	0	69.7	47.7	80.9	91.8	52.5	74.3
OTHER: NUMBER OF CASES	0	0	0	0	0	0	0
ELAPSED TIME	0	0	0	0	0	0	0
TOTAL: NUMBER OF CASES	82	153	179	375	134	60	983
ELAPSED TIME	15.8	10.5	11.0	12.5	19.7	19.3	13.6

TABLE 25

AVERAGE ELAPSED TIME IN MINUTES FOR SEGMENTS OF WEEKDAY FREEWAY TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2050	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	27	416	47	75	134	407	198	106	1410
ELAPSED TIME	5.5	7.0	5.2	4.7	6.9	6.9	6.7	6.5	6.7
FREEWAY									
NUMBER OF CASES	14	208	24	38	62	215	100	53	714
ELAPSED TIME	17.6	9.7	8.9	6.9	9.4	10.8	11.7	13.0	10.5
TOTAL									
NUMBER OF CASES	41	624	71	113	196	622	298	159	2124
ELAPSED TIME	9.6	7.9	6.5	5.4	7.7	8.2	8.4	8.7	8.0

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I.E., TRIPS WITH N-TRIP SEGMENT SEQUENCE)

TABLE 26

AVERAGE ELAPSED TIME IN MINUTES FOR SEGMENTS OF

WEEKEND FREEWAY TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT 0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	TOTAL
NONFREEWAY[1]							
NUMBER OF CASES	50	64	86	138	79	36	453
ELAPSED TIME	5.4	4.7	5.1	7.6	8.8	7.1	6.6
FREEWAY							
NUMBER OF CASES	25	34	42	72	41	19	233
ELAPSED TIME	11.8	9.7	12.0	15.9	21.4	15.4	14.8
TOTAL							
NUMBER OF CASES	75	98	128	210	120	55	686
ELAPSED TIME	7.5	6.4	7.4	10.4	13.1	10.0	9.4

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS

(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 27

DISTRIBUTION OF WEEKDAY TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE NUMBER OF TRIP STOPS WITH ENGINE ON PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2350	
N: NUMBER OF CASES	15	334	92	204	232	551	458	133	2019
NUMBER OF STOPS (ENGINE ON)	5.6	5.3	3.1	3.0	3.7	4.0	2.9	3.3	3.8
NFN: NUMBER OF CASES	12	200	23	33	56	198	89	47	658
NUMBER OF STOPS	4.3	5.6	4.7	4.0	5.1	5.6	4.9	3.6	5.2
NFNFN: NUMBER OF CASES	1	4	0	3	4	7	4	2	25
NUMBER OF STOPS	4.0	8.8	0	6.0	8.3	7.9	9.5	10.5	8.2
OTHER: NUMBER OF CASES	0	0	0	0	0	0	1	1	2
NUMBER OF STOPS	0	0	0	0	0	0	16.0	5.0	10.5
TOTAL: NUMBER OF CASES	28	538	115	240	292	756	552	183	2704
NUMBER OF STOPS	5.0	5.4	3.4	3.2	4.0	4.5	3.3	3.5	4.2

TABLE 28

DISTRIBUTION OF WEEKEND TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE NUMBER OF TRIP STOPS WITH ENGINE ON PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	57	121	142	308	97	43	768
NUMBER OF STOPS (ENGINE ON)	3.0	2.3	2.8	2.5	3.1	4.1	2.7
NFN: NUMBER OF CASES	25	28	34	62	32	16	197
NUMBER OF STOPS	4.5	3.6	3.6	4.8	5.4	3.6	4.4
NFNFN: NUMBER OF CASES	0	4	3	5	5	1	18
NUMBER OF STOPS	0	7.8	5.7	13.8	9.8	9.0	9.7
OTHER: NUMBER OF CASES	0	0	0	0	0	0	0
NUMBER OF STOPS	0	0	0	0	0	0	0
TOTAL: NUMBER OF CASES	82	153	179	375	134	60	983
NUMBER OF STOPS	3.5	2.7	3.0	3.0	3.9	4.0	3.2

TABLE 29

AVERAGE NUMBER OF ENGINE-ON STOPS FOR SEGMENTS OF WEEKDAY FREEWAY TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	27	416	47	75	134	407	198	106	1410
NUMBER OF STOPS	1.8	2.6	2.1	2.0	2.5	2.6	2.2	1.8	2.4
FREEWAY									
NUMBER OF CASES	14	208	24	38	62	215	100	53	714
NUMBER OF STOPS	0.6	0.3	0.2	0.1	0.3	0.4	0.3	0.3	0.3
TOTAL									
NUMBER OF CASES	41	624	71	113	196	622	298	159	2124
NUMBER OF STOPS	1.4	1.8	1.5	1.4	1.8	1.8	1.6	1.3	1.7

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 30

AVERAGE NUMBER OF ENGINE-ON STOPS FOR SEGMENTS OF WEEKEND FREEWAY TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
NONFREEWAY[1]							
NUMBER OF CASES	50	64	86	138	79	36	453
NUMBER OF STOPS	2.0	1.8	1.7	2.4	2.3	1.9	2.1
FREEWAY							
NUMBER OF CASES	25	34	42	72	41	19	233
NUMBER OF STOPS	0.4	0.3	0.4	0.5	0.6	0.5	0.5
TOTAL							
NUMBER OF CASES	75	98	128	210	120	55	686
NUMBER OF STOPS	1.5	1.3	1.3	1.7	1.7	1.4	1.5

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

Tables 31 and 32 show mean measured idling time for weekday and weekend trips while Tables 33 and 34 show similar data for segments of freeway trips.

Most trips in the Minneapolis-St. Paul survey showed zero measured idling time. Over 90% of all trips had less than a minute (91.5% for weekdays and 93.2% for weekends).

Elapsed Time Between Trips

Figures 22 and 23 show the distribution of elapsed time between trips for weekday and weekend. The time scale on each figure is broken in several places: at one hour, to enable a more precise breakdown of shorter intertrip times; and at daily intervals from two to six days to enable the agglomeration of larger intertrip times. Tables 35 and 36 show the breakdown of elapsed time from last trip by time slot and purpose of trip for weekday and weekend trips. Since this quantity is not associated with the trip segment structure but is quite clearly associated with trip purpose, we believe this breakdown is more reasonable than that based upon the time slot/trip segment string criterion used previously.

In addition to this quantity, the survey results also contain data on the incidence of engine-off stops of less than five minutes. This quantity does not show up as an elapsed time between trips since if such a stop occurred, the computer program merged the two trips into a single record. The incidence of such stops was very meager. Table 37 shows the results for weekdays and weekend trips.

TABLE 31

DISTRIBUTION OF WEEKDAY TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE MEASURED IDLING TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N: NUMBER OF CASES	15	334	92	204	232	551	458	133	2019
AVERAGE IDLING TIME	0.3	0.4	0.2	0.1	0.1	0.3	0.3	0.9	0.31
NFN: NUMBER OF CASES	12	200	23	33	56	198	89	47	658
AVERAGE IDLING TIME	0.1	0.4	0.6	0.0	0.5	0.5	0.4	0.1	0.40
NFNFN: NUMBER OF CASES	1	4	0	3	4	7	4	2	25
AVERAGE IDLING TIME	0.0	0.2	0	0	0	3.5	7.6	3.3	2.5
OTHER: NUMBER OF CASES	0	0	0	0	0	0	1	1	2
AVERAGE IDLING TIME	0	0	0	0	0	0	10.8	0	5.4
TOTAL: NUMBER OF CASES	28	538	115	240	292	756	552	183	2704
AVERAGE IDLING TIME	0.2	0.4	0.3	0.1	0.2	0.4	0.4	0.7	0.4

TABLE 32

DISTRIBUTION OF WEEKEND TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE MEASURED IDLING TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	57	121	142	308	97	43	768
AVERAGE IDLING TIME	1.0	3.1	0.3	0.1	0.3	0.3	0.7
NFN: NUMBER OF CASES	25	28	34	62	32	16	197
AVERAGE IDLING TIME	0.8	0.4	0.1	0.3	0.8	0.0	0.4
NFNFN: NUMBER OF CASES	0	4	3	5	5	1	18
AVERAGE IDLING TIME	0	5.0	0.0	3.4	1.5	0.0	2.5
OTHER: NUMBER OF CASES	0	0	0	0	0	0	0
AVERAGE IDLING TIME	0	0	0	0	0	0	0
TOTAL: NUMBER OF CASES	82	153	179	375	134	60	983
AVERAGE IDLING TIME	0.9	2.7	0.3	0.2	0.5	0.2	0.7

TABLE 33

AVERAGE MEASURED IDLING TIME IN MINUTES FOR SEGMENTS
OF WEEKDAY FREEWAY TRIPS IN MINNEAPOLIS-ST. PAUL BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT 0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTAL
NONFREEWAY[1]									
NUMBER OF CASES	27	416	47	75	134	407	198	106	1410
AVG IDLING TIME	0.1	0.2	0.2	0.0	0.2	0.3	0.4	0.1	0.2
FREEWAY									
NUMBER OF CASES	14	208	24	38	62	215	100	53	714
AVG IDLING TIME	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.3
TOTAL									
NUMBER OF CASES	41	624	71	113	196	622	298	159	2124
AVG IDLING TIME	0.1	0.1	0.2	0.0	0.2	0.2	0.3	0.1	0.2

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 34

AVERAGE MEASURED IDLING TIME IN MINUTES FOR SEGMENTS
OF WEEKEND FREEWAY TRIPS IN MINNEAPOLIS-ST. PAUL BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
NONFREEWAY[1]							
NUMBER OF CASES	50	64	86	138	79	36	453
AVG IDLING TIME	0.4	0.2	0.2	0.2	0.4	0.1	0.2
FREEWAY							
NUMBER OF CASES	25	34	42	72	41	19	233
AVG IDLING TIME	0.0	0.1	0.0	0.0	0.1	0.0	0.0
TOTAL							
NUMBER OF CASES	75	98	128	210	120	55	686
AVG IDLING TIME	0.3	0.2	0.1	0.1	0.3	0.1	0.2

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

FIGURE 22

DISTRIBUTION OF ELAPSED TIME BETWEEN TRIPS, WEEKDAY

FIGURE 23

DISTRIBUTION OF ELAPSED TIME BETWEEN TRIPS, WEEKEND

TABLE 35

AVERAGE ELAPSED TIME SINCE LAST TRIP FOR WEEKDAY
TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TIME SLOT AND PURPOSE

PURPOSE OF TRIP	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830 2059	2100-2359	
GO HOME	13 2:46	13 5:51	24 3:07	39 2:31	117 3:59	425 5:14	237 1:11	132 2:24	1000 3:43
GO TO WORK	7 1:38	455 13:46	11 7:13	64 1:13	26 1:06	23 3:49	5 1:34	5 2:51	596 10:76
BUSINESS	3 10:26	26 6:25	41 1:40	47 2:53	45 3:58	21 2:56	26 1:05	4 0:38	213 2:88
SHOPPING	2 26:17	36 11:04	27 6:47	74 2:28	70 3:38	191 3:12	164 1:39	12 2:04	576 3:26
CHURCH, SCHOOL, ETC.	1 3:35	6 13:36	4 3:18	6 1:38	3 2:13	5 3:36	12 1:10	3 1:01	40 3:62
RECREATION	2 3:12	2 6:44	8 6:51	10 3:22	31 3:49	91 2:11	108 1:43	27 1:37	279 2:13
TOTAL	28 4:80	538 12:73	115 3:90	240 2:04	292 3:29	756 4:13	552 1:25	183 2:05	2704 4:83

TABLE 36

AVERAGE ELAPSED TIME SINCE LAST TRIP FOR WEEKEND
TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY BY TIME SLOT AND PURPOSE

PURPOSE OF TRIP	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
GO HOME	25 2:53	42 1:35	68 1:03	144 1:34	66 3:44	39 2:30	384 1:82
GO TO WORK	10 13:12	7 8:00	6 3:20	7 6:32	2 1:21	1 0:07	33 7:67
BUSINESS	6 7:47	4 2:49	5 5:05	8 1:21	4 3:14	0 0	27 3:79
SHOPPING	17 7:14	62 6:40	72 5:47	122 4:39	28 6:37	6 3:29	307 5:36
CHURCH, SCHOOL, ETC.	6 20:08	21 12:46	2 0:58	2 0:55	3 4:26	1 4:41	35 11:47
RECREATION	18 8:13	17 8:50	26 3:35	92 3:18	31 3:52	13 2:28	197 4:11
TOTAL	82 7:65	153 6:05	179 3:33	375 2:87	134 4:05	60 2:39	983 3:98

TABLE 37

NUMBER OF CASES OF ENGINE-OFF STOPS
FOR WEEKDAY AND WEEKEND TRIPS IN MINNEAPOLIS-ST. PAUL SURVEY

NUMBER OF STOPS	NUMBER OF TRIPS	
	WEEKDAY	WEEKEND
0	2537 (94%)	908 (93%)
1	157 (-6%)	71 (-7%)
2	10 (---)	4 (---)

Parking

The results obtained on parking habits during the survey indicate a high likelihood that most residents in the Minneapolis-St. Paul area leave their cars outdoors both at night and between trips. The percentage of indoor parkers is, however, higher than in previously studied cities. Table 38 shows the results for weekdays and weekends. Survey participants were told that only closed garages constituted indoor parking.

TABLE 38

INDOOR AND OUTDOOR PARKING OVERNIGHT AND BETWEEN
TRIPS FOR WEEKDAYS AND WEEKEND DAYS IN MINNEAPOLIS-ST. PAUL SURVEY

	INDOOR	OUTDOOR
WEEKDAYS:		
BETWEEN TRIPS	338 (12.5%)	2366 (87.5%)
OVERNIGHT	230 (39.0%)	360 (61.0%)
WEEKEND DAYS:		
BETWEEN TRIPS	103 (10.5%)	880 (89.5%)
OVERNIGHT	72 (30.5%)	164 (69.5%)

Overnight Fuel Tank Readings

Table 39 shows the percentage of fuel tank readings at the empty, one-quarter, one-half, three-quarter, and full levels for weekdays and weekend days. Survey participants were asked to note the reading at the start of the day's travel.

TABLE 39

OVERNIGHT FUEL TANK READINGS FOR WEEKDAYS AND WEEKEND DAYS IN MINNEAPOLIS-ST. PAUL SURVEY (EXPRESSED AS A PERCENTAGE OF CAR-DAYS FOR THE TWO CATEGORIES)

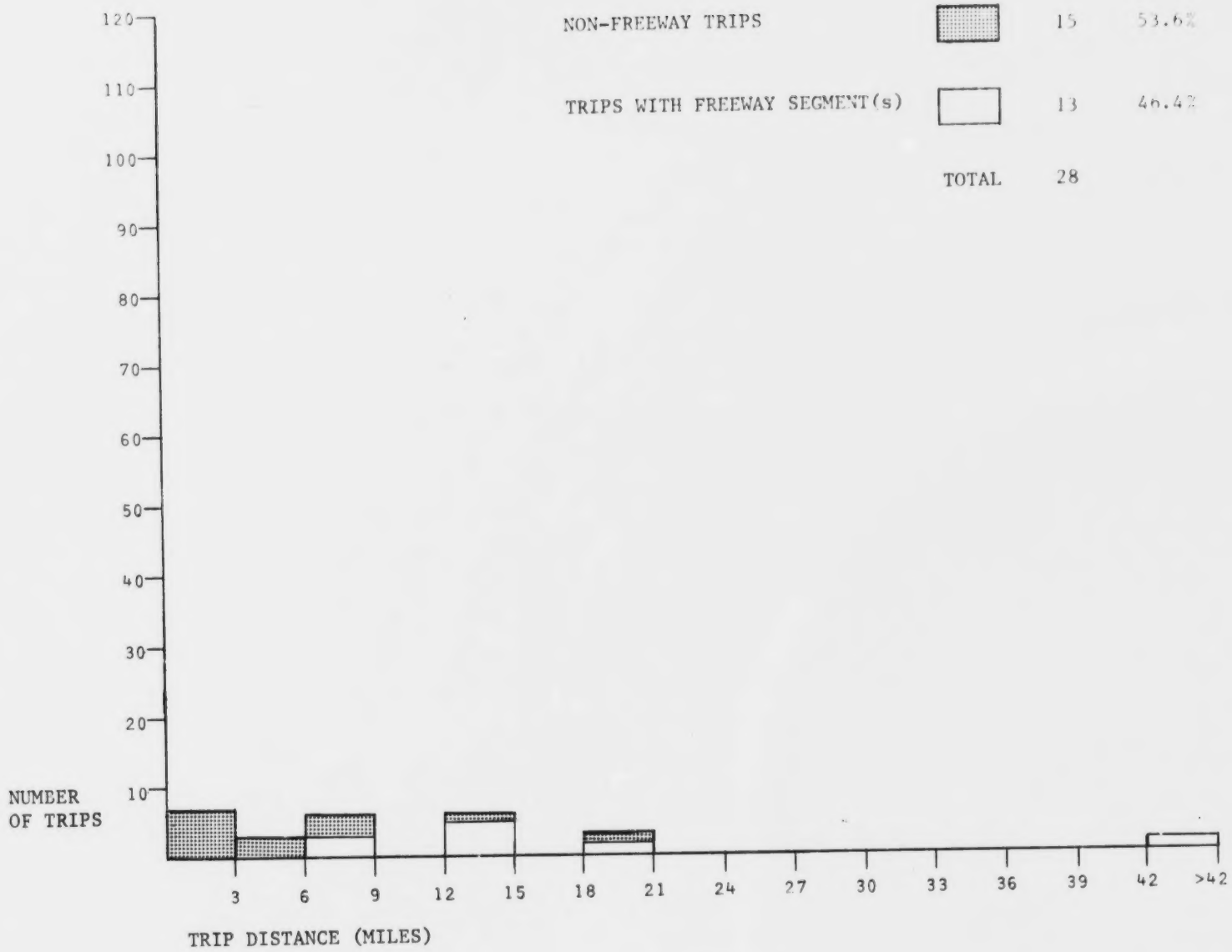
READING	PERCENTAGE OF CAR-DAYS	
	WEEKDAY	WEEKEND
EMPTY	4.7%	5.1%
1/4	25.2%	27.8%
1/2	24.3%	30.1%
3/4	21.2%	20.5%
FULL	19.6%	16.5%

Use of Freeways Versus Surface Streets

Approximately 75% of all weekday trips and 78% of all weekend trips in the Minneapolis-St. Paul survey were made entirely on surface streets. The previous tables showing the breakdown of trip descriptor variables by trip segment string indicate that the freeway trip is both longer and carried out at a greater average speed than the nonfreeway trip.

As in the previous four studies, Figures 24 through 31 were prepared to assist in determining whether the driver tends to use a freeway because of the greater distance he must cover or because of the speed advantage he may obtain. The figures show the distribution of trip distance for nonfreeway and freeway trips by three-mile increments within each of the eight weekday time slots. While all of the charts are not entirely similar, they continue in general to show the trend established in Los Angeles, Houston, Cincinnati, and Chicago. Basically all, with the major exception of time slot one (Figure 24), show an exponentially-shaped frequency function for the combination of all trips, nonfreeway and freeway. The frequency distribution function for freeways tends, however, to be bell-shaped, indicating that the freeway driver tends to select his route because of the distance he must travel.

During the Minneapolis-St. Paul survey, almost 15,000 miles out of the total 27,000 miles driven by survey participants (56%) were on trips that involved freeway segments and 8500 of these were actual freeway miles. The 56% approximates the Los Angeles and Houston values of 68% and 56% respectively, and is above the Cincinnati and Chicago values of 42% and 49% rexpectively.



		NUMBER	PERCENT
NON-FREEWAY TRIPS		15	53.6%
TRIPS WITH FREEWAY SEGMENT(s)		13	46.4%
	TOTAL	28	

FIGURE 24

DISTRIBUTION OF TRIP DISTANCE IM TIME SLOT ONE (0000 - 0559)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

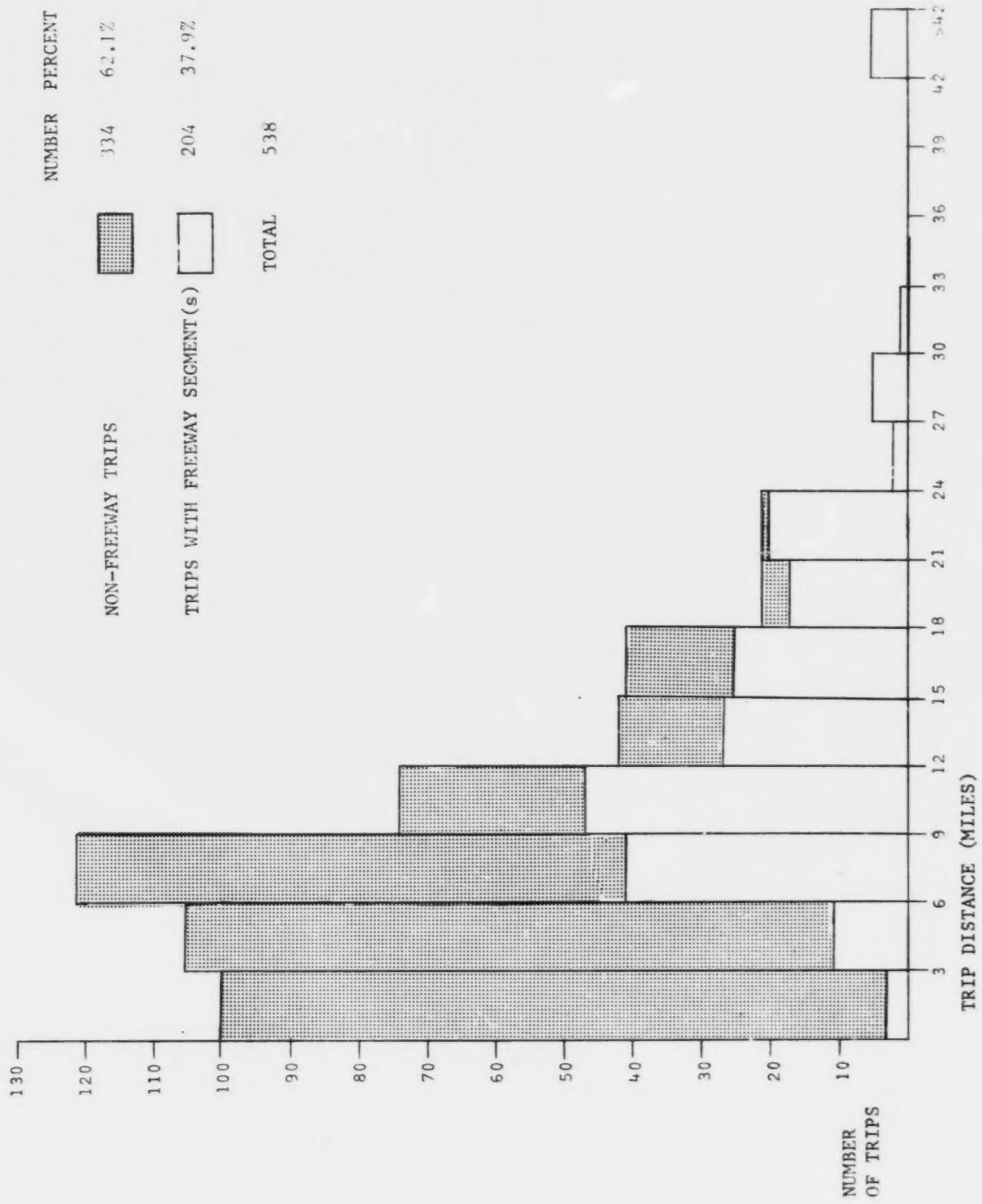


FIGURE 25

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT TWO (0600 - 0859)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

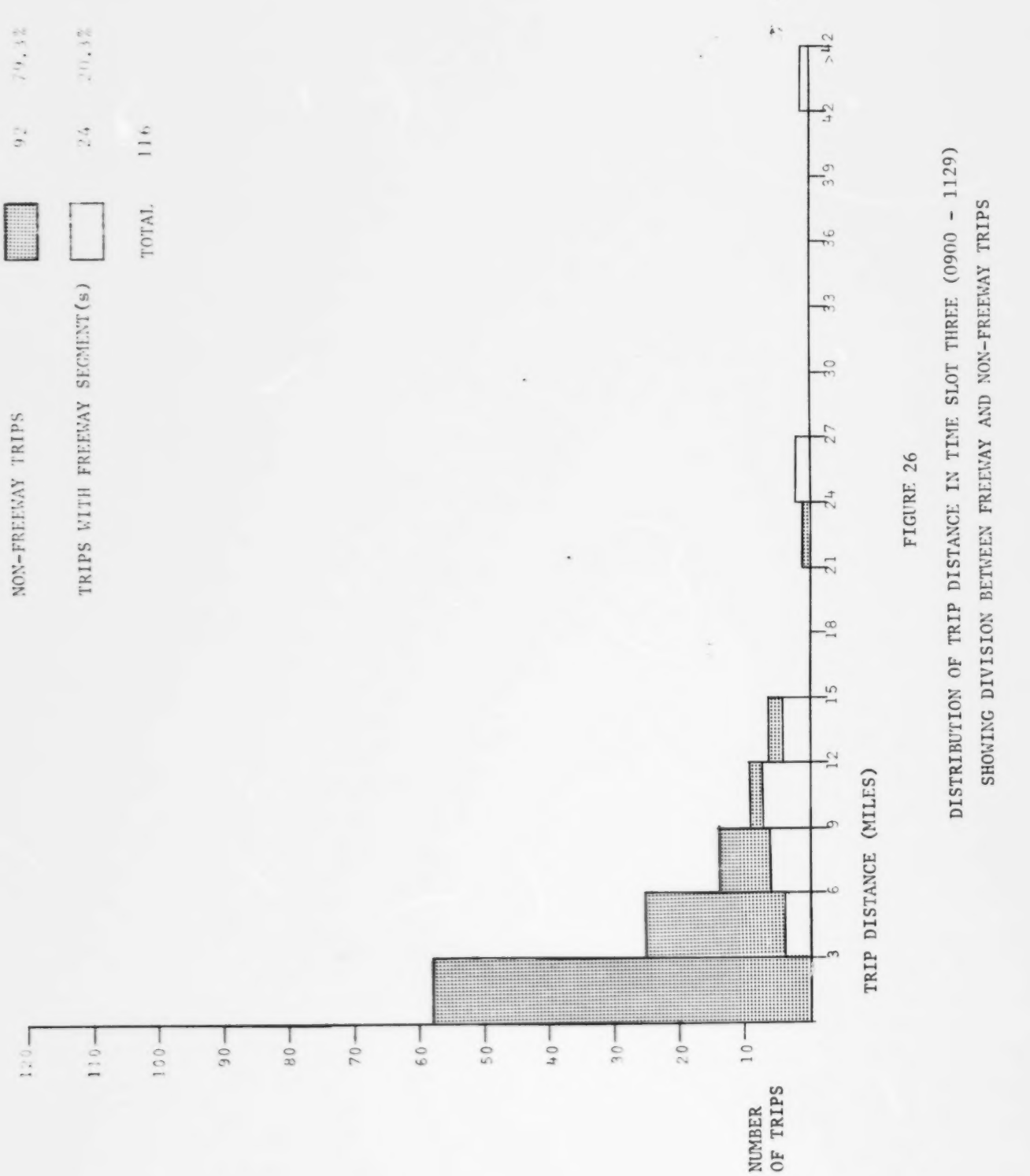
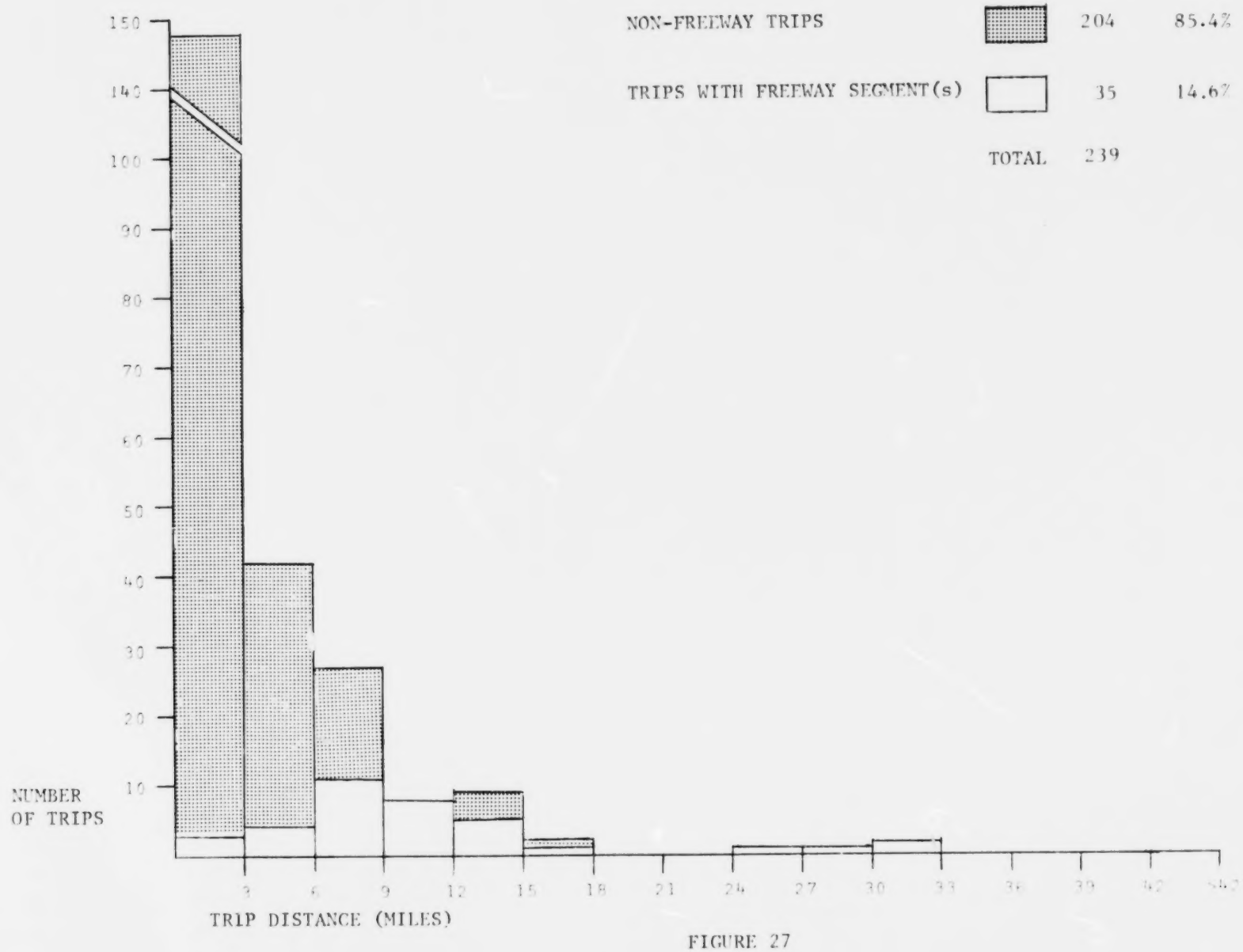


FIGURE 26

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT THREE (0900 - 1129)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS



		NUMBER	PERCENT
NON-FREEWAY TRIPS		204	85.4%
TRIPS WITH FREEWAY SEGMENT(s)		35	14.6%
	TOTAL	239	

FIGURE 27

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT FOUR (1130 - 1329)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

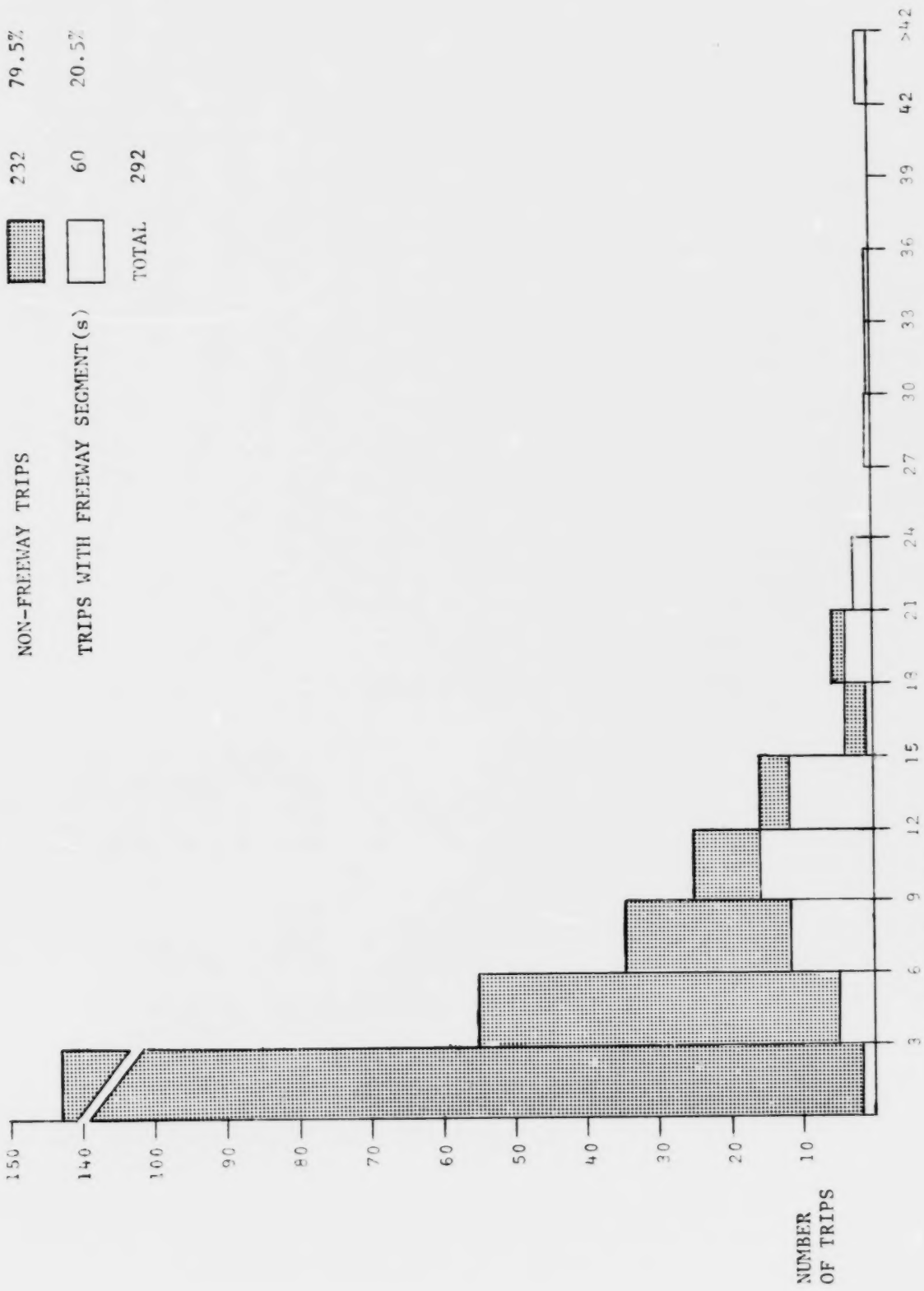
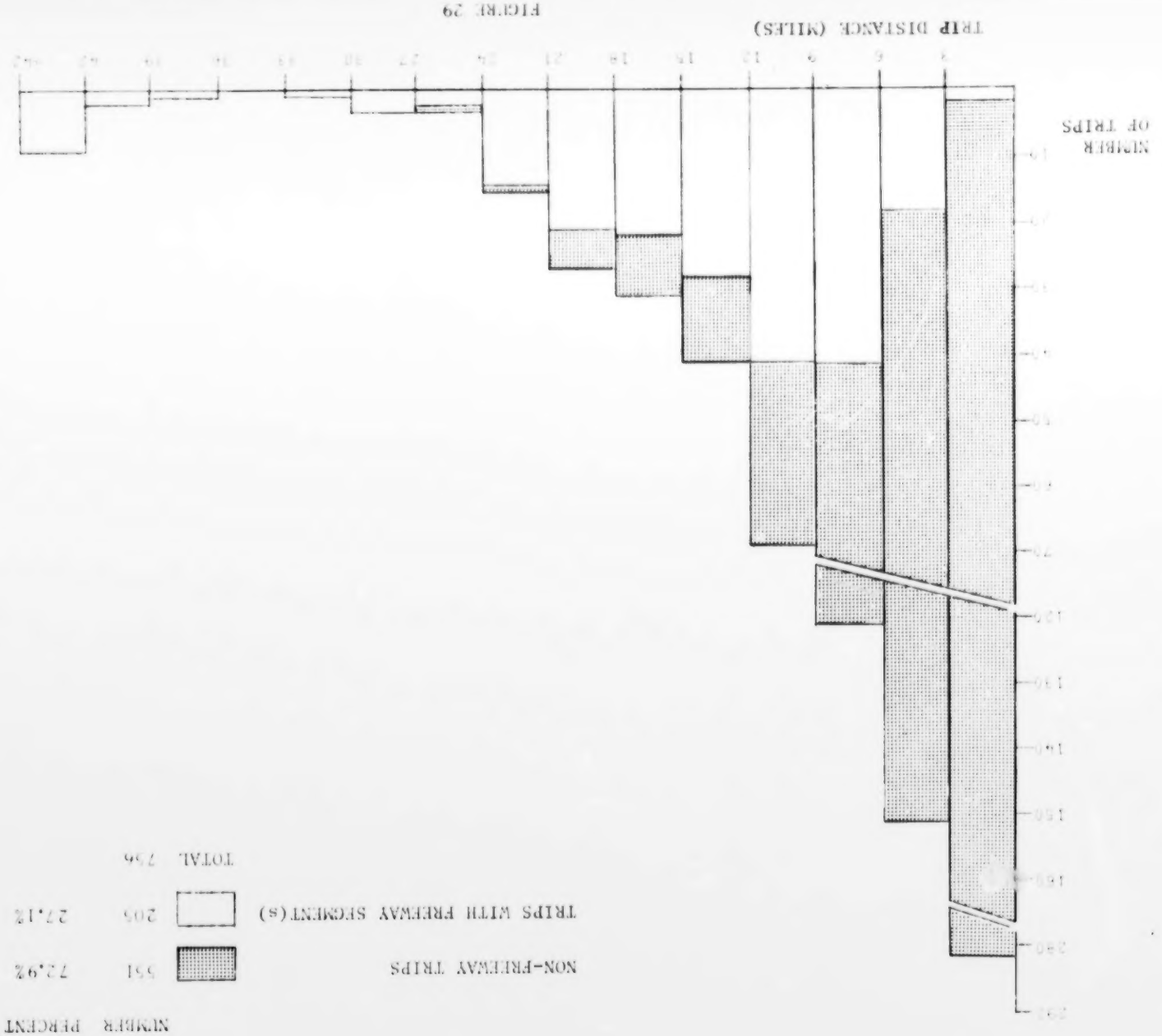


FIGURE 28

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT FIVE (1330 - 1629)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

FIGURE 29

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT SIX (1630 - 1829)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS



	NUMBER	PERCENT
NON-FREEWAY TRIPS	551	72.9%
TRIPS WITH FREEWAY SEGMENT(S)	205	27.1%
TOTAL	756	

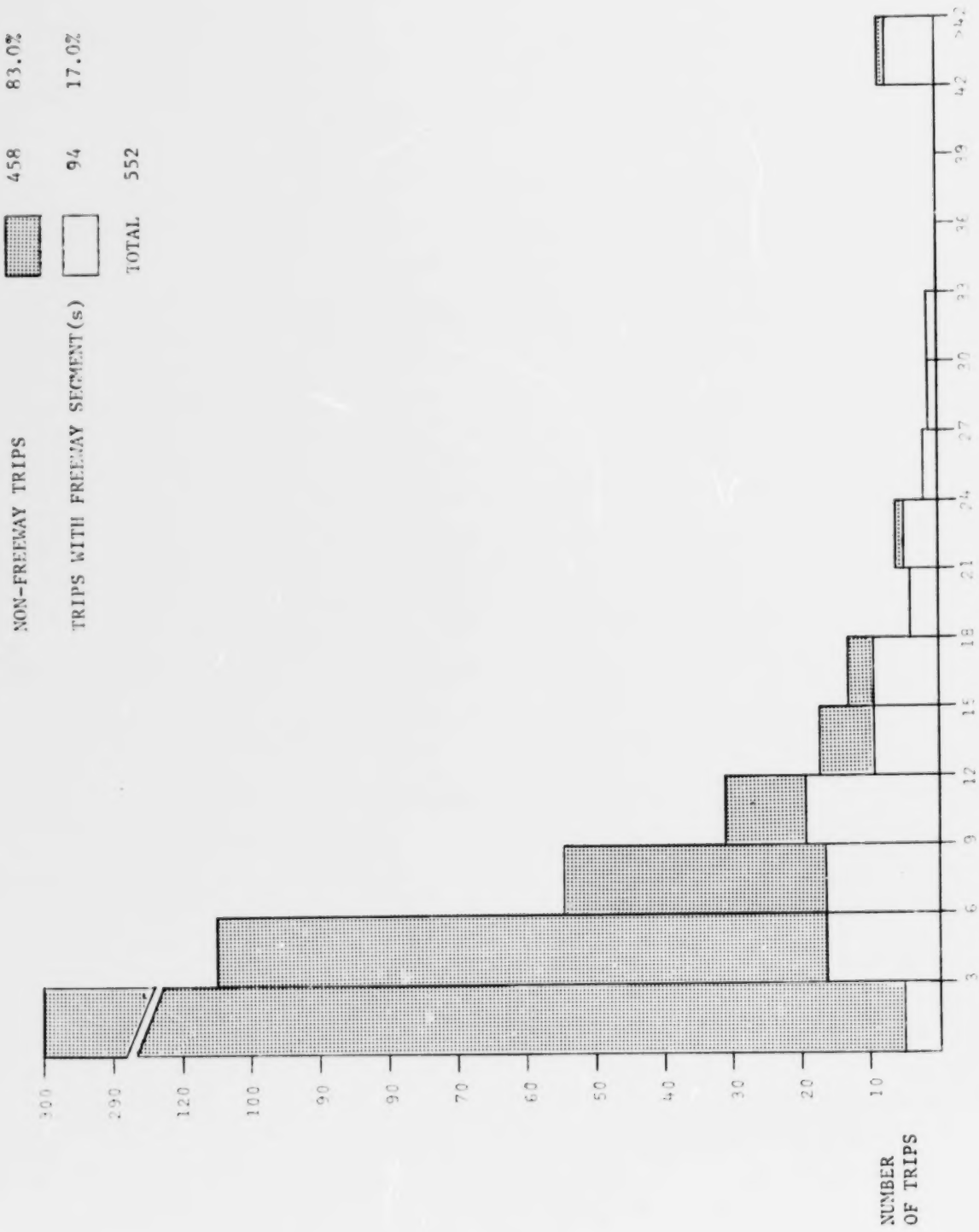
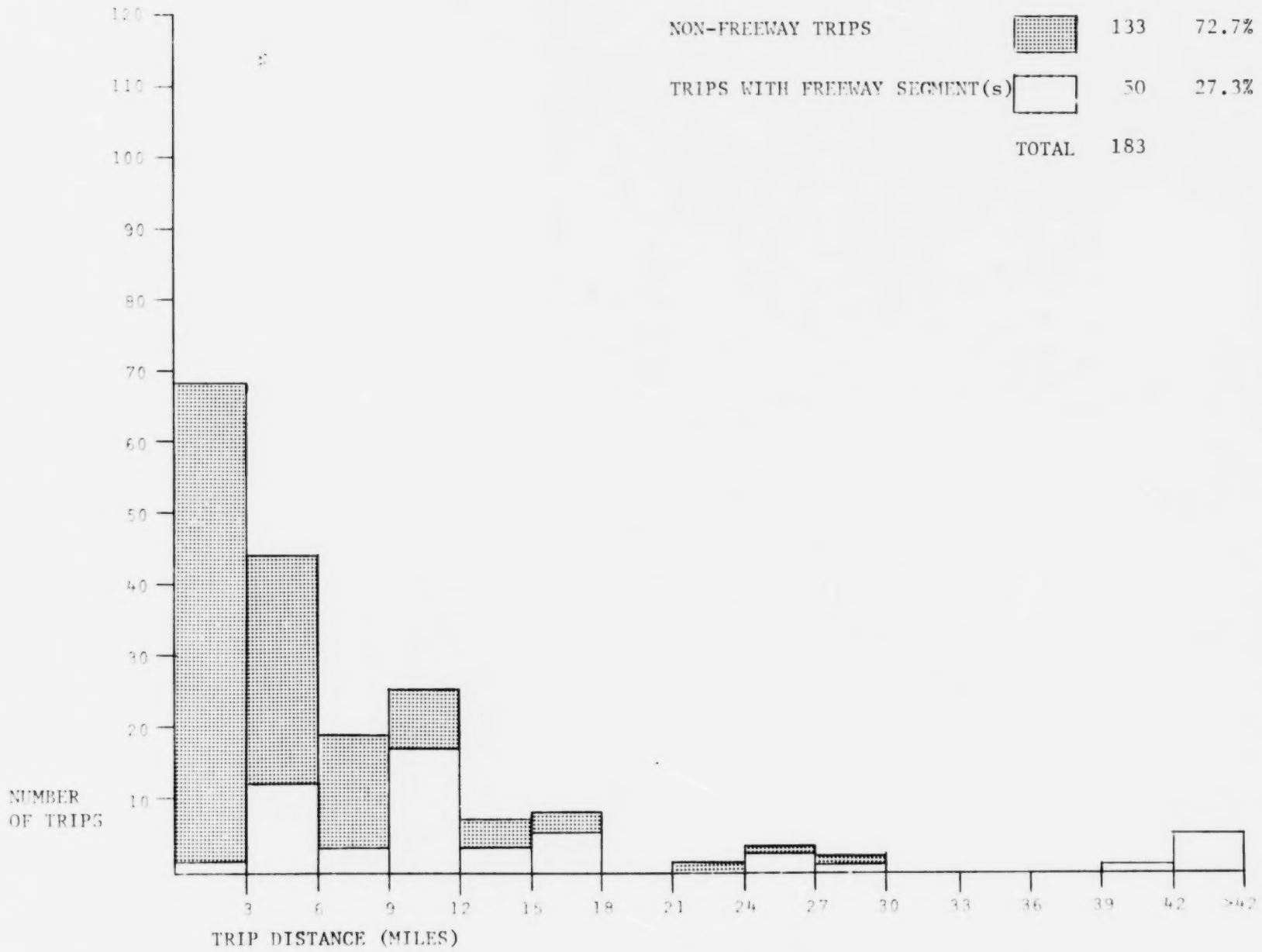


FIGURE 30

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT SEVEN (1830 - 2059)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS



		NUMBER	PERCENT
NON-FREEWAY TRIPS		133	72.7%
TRIPS WITH FREEWAY SEGMENT(s)		50	27.3%
	TOTAL	183	

FIGURE 31

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT EIGHT (2100 - 2359)

SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

COMPARISON OF MINNEAPOLIS-ST. PAUL, CHICAGO, CINCINNATI, HOUSTON AND LOS ANGELES RESULTS

This section of the report compares the results obtained in the Minneapolis-St. Paul survey with those obtained in the Los Angeles, Houston, Cincinnati and Chicago surveys. It is divided into three discussion areas: n-trip day patterns, automobile utilization, and trip descriptors. The principal approach compares the frequency distributions of specific variables obtained in the samples of five cities. Formally stated, the basic hypothesis being tested in each case is whether the five samples are drawn from populations that are homogeneous with respect to the variable being considered. Since the Driving Patterns Survey is concerned with the overall spectrum of driving characteristics rather than with the statistical averages that theoretically represent those statistics in some mathematical sense, we believe that the comparison of distributions provides a more valid basis for statistical inference than the comparison of sample means and standard deviations. Therefore, if statistical tests applied to five samples do not reject the hypothesis of homogeneity, no further testing is carried out. If the hypothesis is rejected, then four-way combinations of Minneapolis-St. Paul and three of the remaining cities are tested to see if they represent homogeneous populations. If the hypothesis is rejected in these tests, three-way and pairwise combinations of Minneapolis-St. Paul with each remaining combination of cities are tested to see which combination most closely resembles Minneapolis-St. Paul in the distributions of the particular variables being tested. If finally, these hypotheses are rejected, the data are examined to determine the reason for rejection and weaker (perhaps less relevant) hypotheses about the equality of sample means are made and tested. In all the statistical tests described, we used an α of 0.05. Thus, if a test indicates that a hypothesis should be rejected, the probability is only 0.05 that the test has rejected a valid hypothesis.

The comparisons of distributions of homogeneity employ the Kolmogorov-Smirnov statistic for variables with underlying distributions that are continuous and the Chi-Square Test of Homogeneity for Variables with discrete distributions. Other tests used for comparisons are described as they are used.

N-Trip Day Patterns

Table 40 shows the percentage of total n-trip days and total car-weekdays represented by those cars that drove the typical n-trip patterns. (In Volume 0, results for Los Angeles indicated n-trip pattern days as a percentage of total car-days. The values in Table 40 have been normalized to total car-weekdays to make them comparable to the Minneapolis-St. Paul, Chicago, Cincinnati, and Houston results.)

The results in Table 40 show that a remarkable degree of homogeneity in n-trip patterns has emerged in the four most recently surveyed cities. N-trip pattern days, expressed as a percentage of all car-weekdays, represented 30% of the Houston sample, 26% of the Cincinnati sample, 24% of the Chicago sample and 27% of the Minneapolis-St. Paul sample. In Los Angeles, the comparable figure was 18%. Chi-square tests on the distribution of n-trip pattern days as a percentage of all n-trip days (pattern and non-pattern) show this homogeneity only for the Minneapolis-St. Paul, Cincinnati and Houston combination. However, a similar test on the distribution of n-trip pattern days as a percentage of all car-weekdays accepts the hypothesis of homogeneity for the combination of Minneapolis-St. Paul, Chicago, Cincinnati and Houston.

Automobile Utilization

Automobile utilization is characterized by the number of trips driven per day, the times at which they are driven, their purpose, and the types of routes taken. The results of the survey in Minneapolis-St. Paul show that

TABLE 40

N-TRIP PATTERN CAR DAYS AS A PERCENTAGE OF ALL N-TRIP DAYS AND ALL CAR-WEEKDAYS
IN THE LOS ANGELES, HOUSTON, CINCINNATI, CHICAGO AND MINNEAPOLIS-ST. PAUL SURVEYS

N-TRIP PATTERN	PERCENT OF N-TRIP DAYS					PERCENT OF CAR-WEEKDAYS				
	LOS ANGELES	HOUSTON	CINCINNATI	CHICAGO	MINNEAPOLIS-ST. PAUL	LOS ANGELES	HOUSTON	CINCINNATI	CHICAGO	MINNEAPOLIS-ST. PAUL
2	44-54%	64-86%	44-57%	62-74%	61-77%	8.8-11.0%	13.5-18%	10.0-12.9%	9.2-11.1%	11.0-13.9%
3	18%	45%	28%	29%	27%	2.3%	5.0%	4.0%	3.5%	3.0%
4 (Evening)	12%	29%	30%	32%	31%	2.2%	5.3%	5.4%	6.7%	6.4%
4 (Noon)	13%	14%	8%	6%	8%	2.3%	2.7%	1.5%	1.1%	1.8%
5 (Evening-Shop)	16%	23%	22%	19%	24%	1.9%	3.1%	2.9%	3.0%	2.9%
5 (Work-Shop)	0	0	13%	0	0	0	0	1.8%	0	0

in most respects automobile utilization is significantly different, in the statistical sense, than in the previously surveyed cities. By this, we mean that the populations of the five cities cannot be considered to be drawn from a homogeneous population.

The numbers of n-trip days (both weekdays and weekend days) in all combinations of the five cities were compared using a chi-square test. The hypothesis of homogeneity was rejected at the $\alpha = 0.05$ level for all combinations except the Minneapolis-St. Paul-Houston pairwise grouping. At the $\alpha = 0.01$ level, the hypothesis was accepted for all combinations of Minneapolis-St. Paul with three of the remaining cities except for the Chicago-Cincinnati and Chicago-Los Angeles pairings.

Tests on the two-way combinations show that the distribution of n-trip days in Minneapolis-St. Paul is most similar to that in Houston, with the second greatest degree of similarity being with the distribution in Cincinnati. This is interesting since the Minneapolis-St. Paul sample showed a modal value of four, the same as that in Chicago. These are the only two samples that have not had a modal value of two.

Chi-square tests on the division of trips between weekdays and weekend days in the five and four-way combinations of cities rejected the hypothesis of homogeneity. In the three-way tests, the hypothesis was not rejected for the combinations of Minneapolis-St. Paul with Chicago and Houston and with Houston and Los Angeles. Pairwise tests showed the greatest degree of simiarity between Minneapolis-St. Paul and Houston.

The time distribution of trips was tested first by time slot, then by the distribution of trip start times over 15-minute intervals throughout the day for both weekday and weekend trips. The time slot loadings in the five cities were tested with a chi-square test. For weekday trips, these tests rejected the hypothesis of homogeneity under all possible city combinations.

Trips in Minneapolis-St. Paul were distributed more similarly to those in Cincinnati than to those in any other city. There were, however, sufficiently more morning and evening rush hour trips, proportionately, in Minneapolis-St. Paul than in Cincinnati that the chi-square test of the two distributions rejected the basic hypothesis. The time distribution of weekend trips by time slot showed greater homogeneity than the weekday distribution. While the five-way test rejected the hypothesis of homogeneity, two of the four four-way tests and five of the six three-way tests failed to reject it. Pairwise comparisons failed to reject the hypothesis at the $\alpha = 0.05$ level for the combinations of Minneapolis-St. Paul with Chicago, Houston and Los Angeles. The test of the pairwise combinations with Cincinnati failed to reject the hypothesis at the $\alpha = 0.01$ level.

All but one of the tests of the city combinations with respect to the distribution of weekday trip start times over 15-minute intervals result in the rejection of the hypothesis of homogeneity. The exception is the pairwise combination of Minneapolis-St. Paul and Cincinnati. The distribution of weekend start times, on the other hand, shows homogeneity between all five cities.

Chi-square tests on the distributions of trip purposes for weekday trips show larger and significant differences for all combinations of cities except the pairwise comparison between Minneapolis-St. Paul and Cincinnati. In the latter case, the test barely rejects the hypothesis of homogeneity at the $\alpha = 0.01$ level. Specific differences were noted in the pairwise comparisons. In comparing Chicago with Minneapolis-St. Paul, there were proportionately more homeward-bound, work and recreation trips in the latter sample, and fewer business trips. When compared with Houston, the Minneapolis-St. Paul sample showed proportionately more home, shopping and recreation trips, fewer work and business trips. Finally, in comparison with Los Angeles, Minneapolis-St. Paul showed proportionately more home, shopping and school trips, and fewer work and business trips.

On weekends, the differences in trip purpose distribution were not so marked. In fact, the chi-square test failed to reject the hypothesis of homogeneity at the $\alpha = 0.01$ level in the Minneapolis-St. Paul, Chicago, and Houston three-way comparison. All remaining tests of greater than pairwise numbers of cities did, however, result in rejection. In pairwise comparison, only the pairing with Los Angeles resulted in total rejection. The other three tests failed to reject the hypothesis at the $\alpha = 0.01$ level.

The weekday division of trips between those that use freeways and those restricted to surface streets is significantly different in Minneapolis-St. Paul than in the previously studied cities. The basic division between the two road types in the Twin Cities in 75% nonfreeway, 25% freeway. This compares to an 80%/20% split in Chicago and Cincinnati and 68%/32% in Houston and a 70%/30% split in Los Angeles.

On weekends, the division of trips between surface streets and freeways changes to 78%/22% in the Minneapolis-St. Paul sample, the same as the Houston ratio. Accordingly, the pairwise test of these two cities fails to reject the hypothesis at the $\alpha = 0.05$ level. Moreover, this ratio is sufficiently close to the Los Angeles ratio of 81%/19%, that the three-way combination of Minneapolis-St. Paul, Los Angeles and Houston can also be considered homogeneous. The ratio for the Cincinnati sample was 86%/14% and for the Chicago sample, 87%/13%. Tests of these cities combined with Minneapolis-St. Paul rejected the basic hypothesis.

Trip Descriptors

The pattern of statistically significant differences that show up in the previously described tests continues in tests of homogeneity with respect to trip descriptor variables in Minneapolis-St. Paul, Chicago, Cincinnati, Houston and Los Angeles. The trip descriptors we will discuss are elapsed time between trips (soak times), trip distance, trip elapsed time, trip stops with engine running, and trip average speed. In addition, tests are made on the results of indoor-outdoor parking and overnight fuel tank readings.

The test for homogeneity of elapsed time between trips on weekdays failed to reject the basic hypothesis for the five-way combination of cities. The same was true for the same distribution for weekend trips.

With respect to trip distance, the five-way comparison fails to reject the hypothesis of homogeneity at the $\alpha = 0.01$ level. One of the four four-way tests (Minneapolis-St. Paul, Chicago, Houston, Los Angeles) rejects the hypothesis at the $\alpha = 0.01$ level. Two of the remaining three reject it at the $\alpha = 0.05$ level. The remaining test (Minneapolis-St. Paul, Chicago, Cincinnati, Houston) fails to reject it at either α level. Direct pairwise comparisons show that trip distances in Minneapolis-St. Paul are distributed most similarly to those in Cincinnati (failure to reject at $\alpha = 0.05$), next most similarly to those in Chicago (failure to reject at $\alpha = 0.01$) and least similarly to those in Los Angeles and Houston (rejection at both α levels). Calculations of the 95% confidence bands for weekday trip distance in the five cities show that the Twin City band overlaps the high end of the Cincinnati band and the low end of the Chicago and Los Angeles bands and lies considerably below the Houston band.

In contrast to the results in the Chicago report, tests on the distributions of trip distances on weekends for all combinations of cities greater than two in number result in rejection of the basic hypothesis at both α levels. Pairwise comparisons show the Twin Cities most comparable to Houston, and next most comparable to Cincinnati. These comparisons fail to reject the basic hypothesis at $\alpha = 0.01$. Comparisons with Chicago and Los Angeles result in rejection at both α levels. Average weekend trip distance in the Minneapolis-St. Paul sample exceeds that in any city to date and the variance in the distribution has a value almost two miles greater than the highest previous value. Consequently, there is little reason to expect that this sample would show homogeneity with the previous samples.

The mean weekday trip elapsed time in the Minneapolis-St-Paul sample was a full two minutes less than the lowest previous value. Moreover, the standard deviation was less than the previous lowest value by the same amount. Consequently, no combination of cities that contains the Twin Cities can be considered homogeneous with respect to weekday trip elapsed time.

On the other hand, none of the tests made on weekend trip elapsed time in the various combinations of cities resulted in a rejection of the hypothesis of homogeneity.

Tests of homogeneity with respect to engine-on stops reject the hypothesis decisively in all city combinations. As mentioned in a previous study, this variable is the most erratically distributed from city to city of any considered. In the Twin Cities, the lack of high values in the distribution of this variable would tend to indicate that traffic flows more freely than in the previously studied cities.

Comparisons of the trip average speeds in the various cities shows that traffic in the Twin Cities also moves more swiftly. The average value of this variable for both weekday and weekend trips is one mile per hour faster than the Houston values, the previous highs. Furthermore, the 95% confidence bands for the means of both weekday and weekend values lie above the 95% confidence for the other cities. Tests of homogeneity of this variable in the various city combinations reject the hypothesis at both α levels in all cases except the Minneapolis-St. Paul-Houston pairwise combination for weekend trips.

The distributions of indoor and outdoor parking were tested twice, first with respect to between trip parking and second with respect to overnight parking. For weekday trips, the hypothesis of homogeneity with respect to between-trip parking was rejected in all cases except the pairing between the Twin Cities and Cincinnati. On weekends, the hypothesis was again rejected except in the pairwise comparisons with Cincinnati and, somewhat surprisingly, Los Angeles

as well as the three-way test combining all of these cities. Tests of overnight parking show similarity only between the Twin Cities and Cincinnati on weekdays. On weekends, Chicago and Los Angeles join Cincinnati in demonstrating a similarity with the Twin Cities sample. In all cases the trend was for more indoor parking by the Minneapolis-St. Paul drivers. Although the survey was carried out in June, the increased incidence of indoor parking may be related to habit acquired during the long Minnesota winters and/or to the availability of indoor facilities necessary to cope with such weather.

Pairwise tests on the distributions of fuel readings for both weekdays and weekends fail to reject the hypothesis of homogeneity for any pairing. However, several combinations of more than two cities do reject the hypothesis because of values lying on either side of the Twin Cities' values. On weekdays the greatest similarity is between Minneapolis-St. Paul and Cincinnati. On weekends, it is between Minneapolis-St. Paul and Houston.

Conclusions

The tests just described are all based on classical statistical techniques. In all cases the critical value of the test statistic is a function of sample size. The underlying theory in all of these tests is that the larger the sample size, the more "precise" the resulting comparison will be. In the case of the Driving Patterns Survey, sample sizes for all variables are large, whether based on number of trips or number of car days. Nevertheless, they are only finite samples from even larger populations. The number of trips per day in any of these samples constitutes only a miniscule percentage of the total number of trips taken on that day in the city being surveyed. Therefore, the degree of real precision in our results--that is, the degree to which our results are truly representative of the driving behavior of the city--depends crucially on how representative of the overall population the

sample is. No measure of the degree of representativeness is available to us. To some extent, the real randomness of the sample must be an article of faith with the statistician in any survey and this holds true for the present study.

We stress this caveat because despite the number of tests described above where the five cities failed to show homogeneity, we do not believe that their failure to do so need necessarily mean that driving behavior is really significantly different in the five cities. If one examines the figures showing distributions of variables in the present and previous volumes from an essentially qualitative standpoint, one cannot help but be impressed by their overall similarity. There are no startling differences between the cities. This is perhaps the most significant finding of the study to date.

APPENDIX

MINNEAPOLIS-ST. PAUL SURVEY PROCEDURES

The survey procedure was designed to obtain data from which typical driving patterns could be derived. Three basic steps were taken in the data gathering phase of the survey: design of the survey sample; selection of the survey participants; and collection of data. Subsequent sections of this Appendix cover each of these steps in detail.

SAMPLE DESIGN

The sample for the Minneapolis-St. Paul Driving Patterns Survey was designed to obtain data on an adequate number of trips to ensure that description of trip variables would be statistically accurate. Fifty Tachograph recording devices previously employed during the Los Angeles, Houston, Cincinnati, and Chicago Driving Patterns Surveys were used to collect data from 50 participating automobiles for one week; on the basis of the Minneapolis-St. Paul population, it was determined that data from 150 vehicles would be a representative sample.

As in the surveys in the other cities, the sample was stratified four ways in terms of residence type (single family and multiple family dwelling) and car ownership (single car and multiple car). These stratification criteria were based on data from the continuing Los Angeles Regional Traffic Study (LARTS), which indicates that trip generation rates for automobiles can be correlated with residence type and car ownership.

The proposed stratification in Los Angeles was based on 1960 Census data. As the study there progressed, however, application forms from prospective participants showed clearly that the 1968 population had changed markedly from the 1960 population with respect to residence type and car ownership. This change necessitated a modification to the stratification of the Los Angeles sample.

Based upon our experience in Los Angeles relative to change in population, it was decided to stratify the sample for the Minneapolis-St. Paul survey according to data provided by application forms received from prospective participants. Percentages in each of the cells in the matrix in Table A-1 are representative averages of the information obtained from the 19 participating organizations in Minneapolis-St. Paul.

TABLE A-1

STRATIFICATION OF THE SAMPLE FOR THE

MINNEAPOLIS-ST. PAUL DRIVING PATTERNS SURVEY

RESIDENCE TYPE	AUTOMOBILES PER HOUSEHOLD	
	ONE	TWO OR MORE
Single Family	31%	51%
Multiple Family	13%	5%

PARTICIPATION SELECTION

The method by which SDC selected participants in the survey was chosen to obtain a representative cross-section of the Minneapolis-St. Paul population. A list of large industrial and commercial organizations in the area was provided by the Greater Minneapolis Chamber of Commerce. From this list 30 firms were contacted and briefed on the nature of the survey. Of the firms contacted, 19 agreed to participate.

Individual volunteers from within each company were recruited by means of Information/Questionnaire Packets which were distributed among the employees (see Volume 0, Appendix II). All the organizations were encouraged to seek as many volunteers as possible; however, the number to be solicited as well as the method to be used to distribute the Information/Questionnaire Packets were left to the discretion of each organization. Generally, those organizations with smaller populations (85 to 500 people) chose to canvas all of

their employees for volunteers; those with a larger population (more than 500 people) decided upon some form of random method of distribution, e.g., distribute one packet to every third name in the telephone book, distribute packets to all personnel who parked their automobiles in the company garage, etc.

A total of 3350 packets were distributed within the participating organizations. Of that number 669 individuals volunteered to participate, from which 150 were chosen as the survey sample (see Table A-2).

DATA COLLECTION

The data collection effort in Minneapolis-St. Paul began on June 6, 1969. Of the 150 individuals chosen as the survey sample, 15 were eliminated for various reasons--mechanical incompatibility between the volunteer's automobile and the Tachograph instrument, failure of individuals to report for the installation, mechanical condition of car, etc. A rainstorm caused the cancellation of installations at one organization altogether. Of the 125 actual installations made, 7 did not provide usable information because of mechanical failures either in the vehicle or the Tachograph.

TABLE A-2

RECRUITING PARTICIPANTS

ORGANIZATION	QUESTIONNAIRES DISTRIBUTED	VOLUNTEERS	SURVEY SAMPLE
American Hoist and Derrick	200	24	10
Carter Day	200	26	10
Control Data	200	26	10
Donaldson Company, Inc.	200	37	10
Ford Motor Company	100	6	0
Hoerner-Waldorf	200	28	10
Honeywell	200	91	20
KTCA-TV	50	9	0
Magnetic Controls	100	15	0
Minnesota Highway Department	200	44	10
National Connector	100	9	0
Northern States Power Company	200	43	10
Northwest Bell Telephone	200	40	10
Prudential Insurance	200	62	10
Rosemont Engineering Company	150	18	0
State Farm Insurance Company	200	45	10
3M	200	47	10
UNIVAC	250	64	10
Webb Publishing Company	200	35	10
TOTALS	3350	669	150

FIGURE A-1 A-1
MINNEAPOLIS-ST. PAUL DRIVING PATTERNS SURVEY
SURVEY ZONES

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4. Title and Subtitle A Survey of Average Driving Patterns in the Minneapolis-St. Paul Urban Area			5. Report Date Feb 13, 70 6.
7. Author(s) R.L. Lamoureux, D.H. Kearin, B.H. Bancroft			8. Performing Organization Rept. No. TM-(L)-4119/004/00
9. Performing Organization Name and Address System Development Corporation 2500 Colorado Avenue Santa Monica, California			10. Project/Task/Work Unit No. CRC-APRAC-CAPE-10-68 11. Contract/Grant No. PH 22-68-56
12. Sponsoring Organization Name and Address Coordinating Research Council, Inc., 30 Rockefeller Plaza, New York, New York 10020, and Environmental Protection Agency, 411 West Chapel Hill Street, Durham, North Carolina			13. Type of Report & Period Covered Final -- Minn-St. Paul 14.

15. Supplementary Notes

Releasable to the public Aug 1971

16. Abstracts

This study was to survey the characteristic use patterns of privately operated automobiles in the Minneapolis-St Paul urban area. The purpose was to obtain data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices.

17. Key Words and Document Analysis. 17a. Descriptors

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Limit Cycles
Vehicular Traffic Control
Emission

17b. Identifiers/Open-Ended Terms

St Paul
Minneapolis

17c. COSATI Field/Group 13B; 13F

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